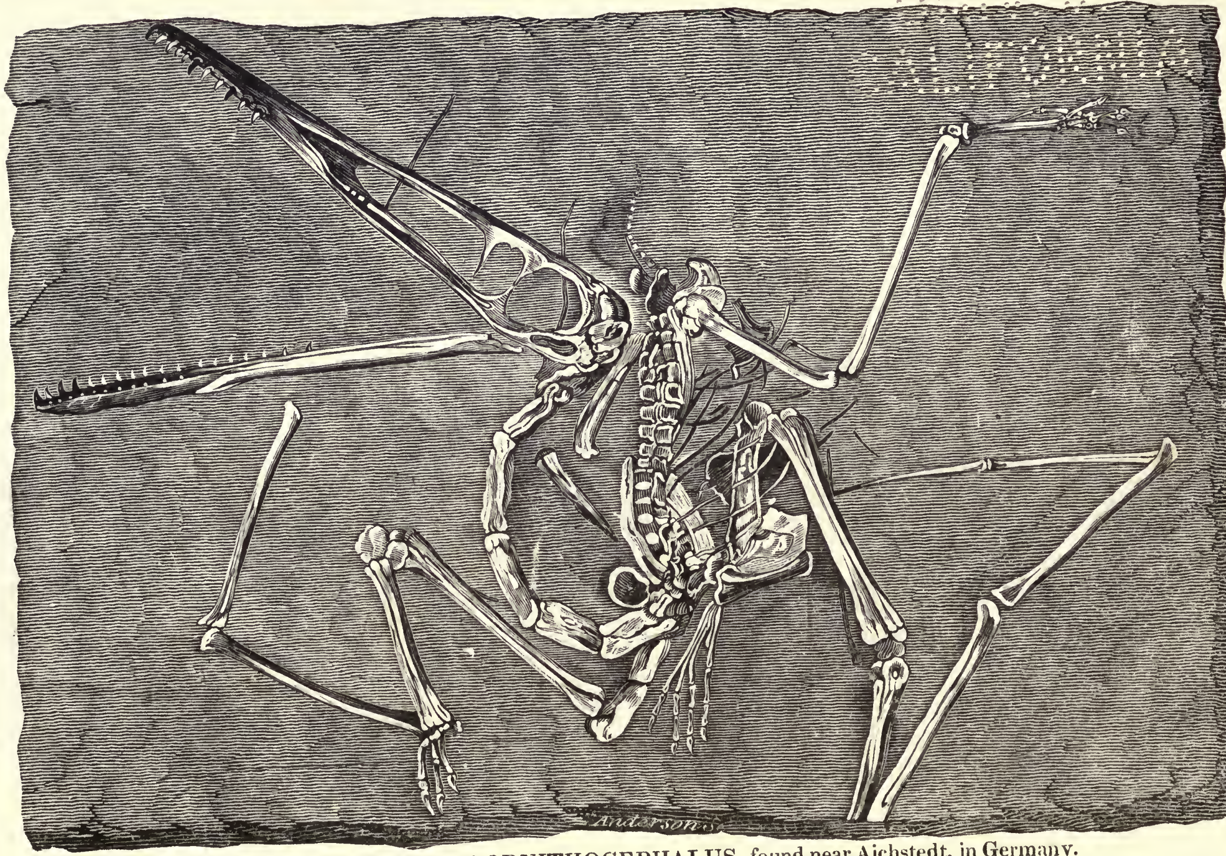
ESSAY

ON THE

THEORY OF THE EARTH.



Extraordinary animal, named ORNITHOCEPHALUS, found near Aichstedt, in Germany.

Tho Smith

ESSAY

ON THE

THEORY OF THE EARTH.

BY M. CUVIER,

PERPETUAL SECRETARY OF THE FRENCH INSTITUTE, PROFESSOR AND ADMINISTRATOR OF THE MUSEUM OF NATURAL HISTORY, &c. &c.

WITH

MINERALOGICAL NOTES,

AND

AN ACCOUNT OF CUVIER'S GEOLOGICAL DISCOVERIES,

BY PROFESSOR JAMESON.

TO WHICH ARE NOW ADDED,

OBSERVATIONS

ON THE

GEOLOGY OF NORTH AMERICA;

ILLUSTRATED

BY THE DESCRIPTION OF VARIOUS ORGANIC REMAINS, FOUND IN THAT PART OF THE WORLD.

BY SAMUEL L. MITCHILL,

Botan. Mineral. et Zoolog. in Univers. Nov. Eborac. Prof. &c. &c.

NEW-YORK:

PUBLISHED BY KIRK & MERCEIN.
NO. 22 WALL-STREET.

Printed by W. A. Mercein, No. 93 Gold-Street.

1818.

PREFACE.

The attention of naturalists was early directed to the investigation of the fossil organic remains so generally and abundantly distributed throughout the strata of which the crust of the earth is composed. It is not, as some writers now imagine, entirely a modern study; for even so early as the time of Leibnitz, we find that philosopher drawing and describing fossil bones. After this period it continued to interest individuals, and engage the particular attention of societies and academies. The Royal Society of London, by the Memoirs of Sloane, Collinson, Lister, Derham, Baker, Grew, Hunter, Jacobs, Plott, Camper, and many others, afforded satisfactory proofs of the importance attached

to this branch of natural history by philosophers in England; and the Memoirs of M. Graydon, in the Transactions of the Royal Irish Academy, show that it was not entirely neglected in Ireland. On the continent of Europe the natural history of petrifactions was also much studied, as appears from the Memoirs of Hollman, Beckman, and Blumenbach, in the Transactions of the Royal Society of Gottingen;—of Gmelin, Pallas, Herrmann, Chappe, in the Memoirs of the Imperial Academy of Science of Petersburgh;—of Geoffroi, Buffon, Daubenton, Faujas, St. Fond, and others of the old French Academy of Sciences;—of Asturc and Riviere, of the Royal Academy of Sciences of Montpellier;—of Collini, of the Academia Theodoro-Palatina, at Manheim, &c. But the geognostical relations of the rocks in which these organic remains are contained were but ill understood, until Werner pointed out the mode of investigating them. His interesting and important views* were circulated from Freyberg,

---

* See Note L.

by the writings and conversations of his pupils, and have contributed materially to the advancement of this branch of natural history in Germany, France, and also in Great Britain. Petrifactions are no longer viewed as objects of mere curiosity, as things isolated and unrelated to the rocks of which the crust of the earth is composed; on the contrary, they are now considered as one of the most important features in the strata of all regions of the earth. By the regularity and determinate nature of their distribution, they afford characters which assist us in discriminating not only single beds, but also whole formations of rocks; and in this respect they are highly interesting to the geognostical inquirer. To the geologist this beautiful branch of natural history opens up numerous and uncommonly curious views of nature in the mineral kingdom: it shows him the commencement of the formation of organic beings,—it points out the gradual succession in the formation of animals, from the almost primæval coral near the primitive strata, through all the wonderful variety of form and structure

observed in shells, fishes, amphibious animals, and birds, to the perfect quadruped of the alluvial land; and it makes him acquainted with a geographical and physical distribution of organic beings in the strata of the globe very different from what is observed to hold in the present state of the organic world. The zoologist views with wonder and amazement those hosts of fossil animals, sometimes so similar to the present living species, at other times so far removed from them in form and structure. He compares the fossil orders, genera, and species with those now inhabiting the earth's surface, or living in its waters, and discovers that there is a whole system of animals in a fossil state different from the present. Even the physiologist, in the various forms, connexions, and relations of the parts of those animals, obtains new facts for his descriptions and reasonings. Such, then, being the nature of this branch of natural history, it is not surprising that, when once understood, it should have many and zealous cultivators, and occupy the talents of men of learning and sagacity. In

our time, Cuvier, the celebrated Professor of Natural History in Paris, has eminently distinguished himself by his numerous discoveries, accurate descriptions, and rational views in this subject. His work on Fossil Organic Remains, of which we have given an account in the following Illustrations, will always remain a monument worthy of its author.

The Essay on the Theory of the Earth, now translated, is the introductory part of the great work of Cuvier. The subject of the *deluge* forms a principal object of this elegant discourse. After describing the principal results at which the theory of the earth, in his opinion, has arrived, he next mentions the various relations which connect the history of the fossil bones of land animals with these results; explains the principles on which is founded the art of ascertaining these bones, or, in other words, of discovering a genus, and of distinguishing a species, by a single fragment of bone; and gives a rapid sketch of the results to which

his researches lead, of the new genera and species which these have been the means of discovering, and of the different formations in which they are contained. Some naturalists, as La Mark, having maintained that the present existing races of quadrupeds are mere modifications or varieties of those ancient races which we now find in a fossil state, modifications which may have been produced by change of climate, and other local circumstances, and since brought to the present great difference by the operation of similar causes during a long succession of ages,—Cuvier shows that the difference between the fossil species and those which now exist, is bounded by certain limits; that these limits are a great deal more extensive than those which now distinguish the varieties of the same species; and, consequently, that the extinct species of quadrupeds are not varieties of the present existing species. This very interesting discussion naturally leads our author to state the proofs of the recent population of the world; of the comparatively

modern origin of its present surface; of the deluge, and the subsequent renewal of human society.

In order to render this Essay more complete and satisfactory, I have illustrated the whole with an extensive series of observations, and have arranged them in such a manner that they will be readily accessible, not only to the naturalist, but also to the general reader.

Since the publication of the former edition of this Essay, many curious discoveries have been made in regard to fossil organic remains; —some of these are included in the Illustrations at the end of the Essay, others want of room forces us to omit. But we cannot allow the present opportunity to pass, without briefly describing that remarkable fossil animal already noticed in a very cursory manner in page 266, as we are now enabled to present the English reader with a representation of it from a drawing of Sommerring, in the *Denkschriften*

der Koniglichen Academie der Wissenschaften zu Munchen, for 1811 and 1812, which has just reached this country.

The fossil animal there represented was found many years ago in the limestone quarries of Aechstedt, and described by the late Collini in the 5th volume of the Actorum Academiæ Theodoro-Palatinæ. He considered it as an extraordinary species of fish. Cuvier, from an inspection of the plate of Collini, was of opinion that it was an amphibious animal; Blumenbach was inclined to view it as a webb-footed bird; and now Sommerring has ascertained, from an actual inspection of the specimen itself, that its characters are very different from those of birds, amphibious animals, or fishes, but agree with those of animals of the class mammalia; in this opinion coinciding with that advanced by a sagacious and profound naturalist, Hermann. It is named by Sommerring *ornithocephalus antiquus*, from the resemblance of its head to that of a bird.

It appears to form one of a series of animals intermediate between the class mammalia and class aves. In the scale of nature, its place appears to be between flying quadrupeds and birds, and certainly it has a more close resemblance to birds than the famed ornithorynchus, or duck-billed quadruped of New Holland. The skeleton represented in the plate is about 10 inches 4 lines long, and appears somewhat compressed and distorted, owing to the contraction and pressure of the limestone in which it is contained. Sommerring is of opinion that it is a flying quadruped analogous to the bat; and of all the families of the genus, most nearly allied to that named pteropus. It differs from the pteropi, however, in having four toes in place of five; and in the circumstance of one only of the toes of the fore feet being elongated, whereas in the pteropi, four of the toes are elongated, one only being short.

The cranium is uncommonly small, the orbits of enormous magnitude, and the jaws longer than the body, and provided with sharp and

slightly bent teeth. The neck is the length of the body, and, like that of most mammiferous animals, composed of seven vertebræ. There are four legs, on each leg four toes, and all of them provided with claws. In the fore legs one of the toes is very much elongated, the other three are short; the hinder legs are also of considerable length, and provided with toes, which are longer than those upon the fore feet. There are no tarsal bones, only metatarsal bones and claws; the tarsal bones appear to have been of a softer nature, and may have been destroyed. There is a distinct tail.

The head, in its general form, very much resembles that of birds of the genus scolopax of Linnæus. From the magnitude of the orbits, it would seem that this animal must have had very large eyes. The small, sharp, and slightly bent teeth, and wide mouth, would intimate that the animal did not live on plants, but rather on large insects, which it would be enabled to catch while on the wing. The great thickness and length of the toe of the fore foot, show

that is power of flying must have been considerable.

All the species of the genus pteropus, to which this animal is allied, are natives of the tropical regions of the earth ; hence it has been inferred that this animal must also have been an inhabitant of a warm climate, but this opinion is destitute of plausibility.

ROBERT JAMESON.

College of Edinburgh,
19*th April*, 1817.

CONTENTS.

PAGE

1. Preliminary Observations 25
2. Plan of this Essay 28
3. Of the first Appearance of the Earth 29
4. First Proofs of Revolutions on the Surface of the Globe 30
5. Proofs that such Revolutions have been numerous 34
6. Proofs that the Revolutions have been sudden 37
7. Proofs of the Occurrence of Revolutions before the Existence of Living Beings 39
8. Examination of the Causes which act at present on the Surface of our Globe 44
9. Of Slips, or Falling Down of the Materials of Mountains 45
10. Of Alluvial Formations 46
11. Of the Formation of Downs 48
12. Of the Formation of Cliffs, or steep Shores 49
13. Of Depositions formed in Water 50
14. Of Stalactites 51
15. Of Lithophytes .... ib.
16. Of Incrustations 52
17. Of Volcanoes 53
18. Of Astronomical Causes of the Revolutions on the Earth's Surface 55

PAGE
19. Of former Systems of Geology........................... 57
20. Diversities of the Geological Systems, and their Causes 63
21. Statement of the Nature and Conditions of the Problem to be solved.. 64
22. Of the Progress of Mineral Geology...................... 67
23. Of the Importance of Extraneous Fossils, or Petrifactions, in Geology..................................... 69
24. High importance of investigating the Fossil Remains of Quadrupeds.. 71
25. Of the small Probability of discovering new Species of the larger Quadrupeds............................... 74
26. Inquiry respecting the Fabulous Animals of the Ancients 85
27. Of the Difficulty of distinguishing the Fossil Bones of Quadrupeds.. 97
28. Results of the Researches respecting the Fossil Bones of Quadrupeds....................................... 109
29. Relations of the Species of Fossil Bones, with the Strata in which they are found.......................... 111
30. Proofs that the extinct Species of Quadrupeds are not Varieties of the present existing Species............ 118
31. Proofs of the recent Population of the World, and that its present Surface is not of very ancient Formation 133
32. Proofs that there are no Human Bones in the Fossil State... 129
*32. Proofs from Traditions, of a great Catastrophe, and subsequent Renewal of Human Society.............. 145
33. Proofs derived from several Miscellaneous Considerations... 161
34. Concluding Reflections..................................... 165
SUPPLEMENT, being an Extract from the Researches of M. de Prony, on the Hydraulic System of Italy; containing an Account of the Displacement of that Part of the Coast of the Adriatic which is occupied by the Mouths of the Po............................. 175

MINERALOGICAL NOTES AND ILLUSTRATIONS.

BY PROFESSOR JAMESON.

	PAGE
A. On the Subsidence of Strata	187
B. On Primitive Rocks	188
C. Crystallized Marbles resting on Shelly Strata	190
D. Rolled Masses upon the Mountains of Jura	ib.
E. Salisbury Craigs	191
F. On the Alluvial Land of the Danish Islands in the Baltic, and on the Coast of Sleswick	ib.
Geest Land	192
Marsch Lands	194
Great Rise of the Ocean	197
Frisian Colony	ib.
Enclosing the Marsches	198
Uniting the Islands	199
Building of Dikes	202
G. On the Sand Flood	205
H. Action of the Sea upon Coasts	208
I. On Coral Islands	210
K. On the Diminution of the Waters of the Ocean	214
L. Werner's Views of the Natural History of Petrifactions	217
M. On the Distribution of Petrifactions in the Different Classes of Rocks	219

TRANSITION ROCKS.

1. Transition Limestone	ib.
2. Greywacke	220
3. Clay Slate	ib.
4. Greywacke Slate	ib.

FLŒTZ ROCKS.

PAGE

I. First Sandstone ... 221
II. First Flœtz Limestone ... 222
1. Alpine Limestone ... ib.
2. Bituminous Marl Slate ... ib.
3. Zechstein ... 223
4. Coal ... ib.
III. Second red or variegated Sandstone ... 224
IV. Second Flœtz Limestone ... 225
V. Third Flœtz Limestone ... 226
VI. Chalk Formation ... 229
VII. Flœtz Trap Rocks ... 232
VIII. Newest Flœtz Trap ... ib.
IX. Newest Flœtz Formations ... 233
X. Alluvial Formations ... ib.

M. Cuvier's Geological Discoveries.

Mineralogy of Paris ... 238

Fossil Organic Remains described by Cuvier, arranged in a Systematic Order.

CLASS.—MAMMALIA.

ORDER.—DIGITATA.

Family. Glires.

Genera. Cavia ... 240
Mus ... ib.

Family. Feræ.

Genera. Ursus ... 241
Canis ... 243
Felis ... ib.
Viverra ... ib.

Family. Bruta.

		PAGE
Genera.	Bradypus	244
	Megalonix	ib.

ORDER.—MARSUPIALIA.

Genera.	Didelphis	245

ORDER.—SOLIDUNGULA.

Genera.	Equus	ib.

ORDER.—BISULCA.

Genera.	Cervus	ib.
	Bos	248

ORDER.—MULTUNGULA.

Genera.	Rhinoceros	250
	Hippopotamus	ib.
	Tapir	251
	Elephant or Mammoth	252
	Sus	255
	Mastodon	ib.
	Palæotherium	259
	Anoplotherium	260

ORDER.—PALMATA.

Family. Glires.

Genera.	Castor	261

Family. Feræ.

Genera.	Phoca	ib.

Family. Bruta.

Genera.	Lamantin	ib.

CLASS.—AVES.

		PAGE
Sturnus.	Starling	262
Coturnix.	Quail	ib.
Sterna.	Tern	ib.
Grallæ.	Wadders	ib.
Pelicanus.	Pelican	ib.

CLASS.—AMPHIBIA.

ORDER.—REPTILES.

Genera.	Testudo—Tortoise	ib.
	Crocodilus	263
	Monitor	264
	Salamandra	265
	Bufo. Toad	266
	Saurus	ib.

CLASS.—PISCES.

Genera.	Amia	267
	Mormyrus	ib.
	Pæcilia	ib.
	Sparus	ib.

Osseous Conglomerate.

1. Gibraltar .... ib.
2. Cette .... ib.
3. Nice and Antibes .... ib.
4. Corsica 269
5. Dalmatia .... ib.
6. Island of Cerigo .... ib.
7. Concud, in Arragon 270
8. Vicentine and Veronese .... ib.

Geological Speculations .... ib.

Mineralogical Description of the Country around Paris 271

Chalk Formation 272

PAGE
Plastic Clay Formation 273
Marine Limestone Formation 274
First System of Strata .... ib.
Second System of Strata 275
Third System of Strata 276
Fourth System of Strata 277
Siliceous Limestone without Shells .... ib.
Gypsum Formation and Marine Marl 278
Sandstone and Sand without Shells 285
Upper Marine Sandstone and Sand .... ib.
Millstone without Shells 286
Flint and Siliceous Limestone 288
Alluvial 291
General Observations 292

MINERALOGY OF THE SOUTH OF ENGLAND.

1. Isle of Wight Basin 295
2. London Basin .... ib.

FORMATIONS.

Chalk 296
1. Lower Marine Formation, including the Sand and Plastic Clay and the London or Blue Clay 297
2. Lower Fresh Water Formation 303
3. Upper Marine Formation 304
4. Upper Fresh Water Formation 307
5. Alluvial Formations 308
Formations above Chalk 311
Formations below Chalk 313

Letter from Mr. Marsden to Professor Jameson 316

The Plate of the ORNITHOCEPHALUS to front the Title Page.

ESSAY

ON

THE THEORY OF THE EARTH.

§ 1. *Preliminary Observations.*

IT is my object, in the following work, to travel over ground which has as yet been little explored, and to make my reader acquainted with a species of Remains, which, though absolutely necessary for understanding the history of the globe, have been hitherto almost uniformly neglected.

As an antiquary of a new order, I have been obliged to learn the art of deciphering and restoring these remains, of discovering and bringing together, in their primitive arrangement, the scattered and mutilated fragments of which they are composed, of reproducing, in all their original proportions and characters, the animals to which these

fragments formerly belonged, and then of comparing them with those animals which still live on the surface of the earth; an art which is almost unknown, and which presupposes, what had scarcely been obtained before, an acquaintance with those laws which regulate the coexistence of the forms by which the different parts of organized beings are distinguished. I had next to prepare myself for these inquiries by others of a far more extensive kind, respecting the animals which still exist. Nothing, except an almost complete review of creation in its present state, could give a character of demonstration to the results of my investigation in its ancient state; but that review has afforded me, at the same time, a great body of rules and affinities which are no less satisfactorily demonstrated; and the whole animal kingdom has been subjected to new laws in consequence of this Essay on a small part of the theory of the earth.*

The importance of the truths which have been developed in the progress of my labours, has contributed equally with the novelty of my principal results to sustain and encourage my efforts. May it have a similar effect on the mind of the reader, and induce him to follow me patiently through the difficult paths in which I am under the necessity of leading him!

* This will be seen more at large in the extensive work upon Comparative Anatomy, in which I have been employed for more than twenty-five years, and which I intend soon to prepare for publication.

The ancient history of the globe, which is the ultimate object of all these researches, is also of itself one of the most curious subjects that can engage the attention of enlightened men; and if they take any interest in examining, in the infancy of our species, the almost obliterated traces of so many nations that have become extinct, they will doubtless take a similar interest in collecting, amidst the darkness which covers the infancy of the globe, the traces of those revolutions which took place anterior to the existence of all nations.

We admire the power by which the human mind has measured the motions of globes which nature seemed to have concealed for ever from our view: Genius and science have burst the limits of space, and a few observations, explained by just reasoning, have unveiled the mechanism of the universe. Would it not also be glorious for man to burst the limits of time, and, by a few observations, to ascertain the history of this world, and the series of events which preceded the birth of the human race? Astronomers, no doubt, have advanced more rapidly than naturalists; and the present period, with respect to the theory of the earth, bears some resemblance to that in which some philosophers thought that the heavens were formed of polished stone, and that the moon was no larger than the Peloponnesus; but, after Anaxagoras, we have had our Copernicuses, and our Keplers, who pointed out the way to Newton; and why should not natural history also have one day its Newton?

2. *Plan of this Essay.*

What I now offer comprehends but a few of the facts which must enter into the composition of this ancient history. But these few are important; many of them are decisive; and I hope that the rigorous methods which I have adopted for the purpose of establishing them, will make them be considered as points so determinately fixed as to admit of no departure from them. Though this hope should only be realized with respect to some of them, I shall think myself sufficiently rewarded for my labour.

In this preliminary discourse I shall describe the whole of the results at which the theory of the earth seems to me to have arrived. I shall mention the relations which connect the history of the fossil bones of land animals with these results, and the considerations which render their history peculiarly important. I shall unfold the principles on which is founded the art of ascertaining these bones, or, in other words, of discovering a genus and of distinguishing a species by a single fragment of bone,—an art on the certainty of which depends that of the whole work. I shall give a rapid sketch of the results to which my researches lead, of the new species and genera which these have been the means of discovering, and of the different strata in which they are found deposited.

And as the difference between these species and the species which still exist is bounded by certain limits, I shall show that these limits are a great deal more extensive than those which now distinguish the varieties of the same species; and shall then point out how far these varieties may be owing to the influence of time, of climate, or of domestication.

In this way I shall be prepared to conclude that great events were necessary to produce the more considerable differences which I have discovered: I shall next take notice of the particular modifications which my performance should introduce into the hitherto received opinions respecting the primitive history of the globe; and, last of all, I shall inquire how far the civil and religious history of different nations corresponds with the results of an examination of the physical history of the earth, and with the probabilities afforded by such examination concerning the period at which societies of men had it in their power to take up fixed abodes, to occupy fields susceptible of cultivation, and consequently to assume a settled and durable form.

§ 3. *Of the first appearance of the Earth.*

When the traveller passes through those fertile plains where gently-flowing streams nourish in their course an abundant vegetation, and where the

soil, inhabited by a numerous population, adorned with flourishing villages, opulent cities, and superb monuments, is never disturbed except by the ravages of war and the oppression of tyrants, he is not led to suspect that nature also has had her intestine wars, and that the surface of the globe has been much convulsed by successive revolutions and various catastrophes. But his ideas change as soon as he digs into that soil which presented such a peaceful aspect, or ascends the hills which border the plain; they are expanded, if I may use the expression, in proportion to the expansion of his view; and they begin to embrace the full extent and grandeur of those ancient events to which I have alluded, when he climbs the more elevated chains whose base is skirted by these first hills, or when, by following the beds of the descending torrents, he penetrates into their interior structure, which is thus laid open to his inspection.

§ 4. *First Proofs of Revolutions on the Surface of the Globe.**

The lowest and most level parts of the earth, when penetrated to a very great depth, exhibit nothing but horizontal strata composed of various substances, and containing almost all of them innumerable marine productions. Similar strata,

* Note A. at the end of the Essay.

with the same kind of productions, compose the hills even to a great height. Sometimes the shells are so numerous as to constitute the entire body of the stratum. They are almost everywhere in such a perfect state of preservation, that even the smallest of them retain their most delicate parts, their sharpest ridges, and their finest and tenderest processes. They are found in elevations far above the level of every part of the ocean, and in places to which the sea could not be conveyed by any existing cause. They are not only enclosed in loose sand, but are often incrusted and penetrated on all sides by the hardest stones. Every part of the earth, every hemisphere, every continent, every island of any size, exhibits the same phenomenon. We are therefore forcibly led to believe, not only that the sea has at one period or another covered all our plains, but that it must have remained there for a long time, and in a state of tranquillity; which circumstance was necessary for the formation of deposits so extensive, so thick, in part so solid, and containing exuviæ so perfectly preserved.

The time is past for ignorance to assert that these remains of organized bodies are mere *lusus naturæ*,—productions generated in the womb of the earth by its own creative powers. A nice and scrupulous comparison of their forms, of their contexture, and frequently even of their composition, cannot detect the slightest difference between

these shells and the shells which still inhabit the sea. They have therefore once lived in the sea, and been deposited by it; the sea consequently must have rested in the places where the deposition has taken place. Hence it is evident the basin or reservoir containing the sea has undergone some change at least, either in extent, or in situation, or in both. Such is the result of the very first search, and of the most superficial examination.

The traces of revolutions become still more apparent and decisive when we ascend a little higher, and approach nearer to the foot of the great chains of mountains. There are still found many beds of shells; some of these are even larger and more solid; the shells are quite as numerous and as entirely preserved; but they are not of the same species with those which were found in the less elevated regions. The strata which contain them are not so generally horizontal; they have various degrees of inclination, and are sometimes situated vertically. While in the plains and low hills it was necessary to dig deep in order to detect the succession of the strata, here we perceive them by means of the valleys which time or violence has produced, and which disclose their edges to the eye of the observer. At the bottom of these declivities, huge masses of their *debris* are collected, and form round hills, the height of which is augmented by the operation of every thaw and of every storm.

These inclined or vertical strata, which form the ridges of the secondary mountains, do not rest on the horizontal strata of the hills which are situated at their base, and serve as their first steps; but, on the contrary, are situated underneath them. The latter are placed upon the declivities of the former. When we dig through the horizontal strata in the neighbourhood of the inclined strata, the inclined strata are invariably found below. Nay sometimes, when the inclined strata are not too much elevated, their summit is surmounted by horizontal strata. The inclined strata are therefore more ancient than the horizontal strata. And as they must necessarily have been formed in a horizontal position, they have been subsequently shifted into their inclined or vertical position, and that too before the horizontal strata were placed above them.

Thus the sea, previous to the formation of the horizontal strata, had formed others, which, by some means, have been broken, lifted up, and overturned in a thousand ways. There had therefore been also at least one change in the basin of that sea which preceded ours; it had also experienced at least one revolution; and as several of these inclined strata which it had formed first, are elevated above the level of the horizontal strata which have succeeded and which surround them, this revolution, while it gave them their present inclination, had also caused them to project above the level of

the sea, so as to form islands, or at least rocks and inequalities; and this must have happened whether one of their edges was lifted up above the water, or the depression of the opposite edge caused the water to subside. This is the second result, not less obvious, nor less clearly demonstrated, than the first, to every one who will take the trouble of studying carefully the remains by which it is illustrated and proved.

§ 5. *Proofs that such Revolutions have been numerous.*

If we institute a more detailed comparison between the various strata and those remains of animals which they contain, we shall soon discover still more numerous differences among them, indicating a proportional number of changes in their condition. The sea has not always deposited stony substances of the same kind. It has observed a regular succession as to the nature of its deposits; the more ancient the strata are, so much the more uniform and extensive are they; and the more recent they are, the more limited are they, and the more variation is observed in them at small distances. Thus the great catastrophes which have produced revolutions in the basin of the sea, were preceded, accompanied, and followed by changes in the nature of the fluid and of the substances which it held in solution; and when the surface of the seas came to be divided by islands and project-

ing ridges, different changes took place in every separate basin.

Amidst these changes of the general fluid, it must have been almost impossible for the same kind of animals to continue to live:—nor did they do so in fact. Their species, and even their genera, change with the strata; and although the same species occasionally recur at small distances, it is generally the case that the shells of the ancient strata have forms peculiar to themselves; that they gradually disappear, till they are not to be seen at all in the recent strata, still less in the existing seas, in which, indeed, we never discover their corresponding species, and where several, even of their genera, are not to be found; that, on the contrary, the shells of the recent strata resemble, as it respects the genus, those which still exist in the sea; and that in the last-formed and loosest of these strata, there are some species which the eye of the most expert naturalists cannot distinguish from those which at present inhabit the ocean.

In animal nature, therefore, there has been a succession of changes corresponding to those which have taken place in the chemical nature of the fluid; and when the sea last receded from our continent, its inhabitants were not very different from those which it still continues to support.

Finally, if we examine with greater care these remains of organized bodies, we shall discover, in the midst even of the most ancient secondary strata, other strata that are crowded with animal or vegetable productions, which belong to the land and to fresh water; and amongst the most recent strata, that is, the strata which are nearest the surface, there are some of them in which land animals are buried under heaps of marine productions. Thus the various catastrophes of our planet have not only caused the different parts of our continent to rise by degrees from the basin of the sea, but it has also frequently happened, that lands which had been laid dry have been again covered by the water, in consequence either of these lands sinking down below the level of the sea, or of the sea being raised above the level of the lands. The particular portions of the earth also which the sea has abandoned by its last retreat, had been laid dry once before, and had at that time produced quadrupeds, birds, plants, and all kinds of terrestrial productions; it had then been inundated by the sea, which has since retired from it, and left it to be occupied by its own proper inhabitants.

The changes which have taken place in the productions of the shelly strata have not, therefore, been entirely owing to a gradual and general retreat of the waters, but to successive irruptions and retreats, the final result of which, however, has been an universal depression of the level of the sea.

§ 6. *Proofs that the Revolutions have been sudden.*

These repeated irruptions and retreats of the sea have neither been slow nor gradual; most of the catastrophes which have occasioned them have been sudden; and this is easily proved, especially with regard to the last of them, the traces of which are most conspicuous. In the northern regions it has left the carcasses of some large quadrupeds which the ice had arrested, and which are preserved even to the present day with their skin, their hair, and their flesh. If they had not been frozen as soon as killed they must quickly have been decomposed by putrefaction. But this eternal frost could not have taken possession of the regions which these animals inhabited except by the same cause which destroyed them;* this cause, therefore, must have been as sudden as its effect. The breaking to pieces and overturnings of the strata, which happened in former catastrophes, show plainly enough that they were sudden and violent like the last; and the heaps of *debris* and rounded pebbles which are found in various places

---

* The two most remarkable phenomena of this kind, and which must for ever banish all idea of a slow and gradual revolution, are the rhinoceros, discovered in 1771 in the banks of the *Vilhoui*, and the elephant recently found by M. Adams near the mouth of the *Lena*. This last retained its flesh and skin, on which was hair of two kinds; one short, fine, and crisped, resembling wool, and the other like long bristles. The flesh was still in such high preservation, that it was eaten by dogs.

among the solid strata, demonstrate the vast force of the motions excited in the mass of waters by these overturnings. Life, therefore, has been often disturbed on this earth by terrible events—calamities which, at their commencement, have perhaps moved and overturned to a great depth the entire outer crust of the globe, but which, since these first commotions, have uniformly acted at a less depth and less generally. Numberless living beings have been the victims of these catastrophes; some have been destroyed by sudden inundations, others have been laid dry in consequence of the bottom of the seas being instantaneously elevated. Their races even have become extinct, and have left no memorial of them except some small fragment which the naturalist can scarcely recognise.

Such are the conclusions which necessarily result from the objects that we meet with at every step of our inquiry, and which we can always verify by examples drawn from almost every country. Every part of the globe bears the impress of these great and terrible events so distinctly, that they must be visible to all who are qualified to read their history in the remains which they have left behind.

But what is still more astonishing and not less certain, there have not been always living creatures on the earth, and it is easy for the observer

to discover the period at which animal productions began to be deposited.

§ 7. *Proofs of the Occurrence of Revolutions before the Existence of Living Beings.*

As we ascend to higher points of elevation, and advance towards the lofty summits of the mountains, the remains of marine animals, that multitude of shells we have spoken of, begin very soon to grow rare, and at length disappear altogether. We arrive at strata of a different nature, which contain no vestige at all of living creatures. Nevertheless their crystallization, and even the nature of their strata, show that they also have been formed in a fluid; their inclined position and their slopes show that they also have been moved and overturned; the oblique manner in which they sink under the shelly strata shows that they have been formed before these; and the height to which their bare and rugged tops are elevated above all the shelly strata, shows that their summits have never again been covered by the sea since they were raised up out of its bosom.

Such are those primitive or primordial mountains which traverse our continents in various directions, rising above the clouds, separating the basins of the rivers from one another, serving, by means of their eternal snows, as reservoirs for feeding the springs, and forming in some measure the

skeleton, or, as it were, the rough frame-work of the earth.

The sharp peaks and rugged indentations which mark their summits, and strike the eye at a great distance, are so many proofs of the violent manner in which they have been elevated. Their appearance in this respect is very different from that of the rounded mountains and the hills with flat surfaces, whose recently formed masses have always remained in the situation in which they were quietly deposited by the sea which last covered them.

These proofs become more obvious as we approach. The valleys have no longer those gently sloping sides, or those alternately salient and reentrant angles opposite to one another, which seem to indicate the beds of ancient streams. They widen and contract without any general rule; their waters sometimes expand into lakes, and sometimes descend in torrents; and here and there the rocks, suddenly approaching from each side, form transverse dikes, over which the waters fall in cataracts. The shattered strata of these valleys expose their edges on one side, and present on the other side large portions of their surface lying obliquely; they do not correspond in height, but those which on one side form the summit of the declivity, often dip so deep on the other as to be altogether concealed.

Yet, amidst all this confusion, some naturalists have thought that they perceived a certain degree of order prevailing, and that among these immense beds of rocks, broken and overturned though they be, a regular succession is observed, which is nearly the same in all the different chains of mountains. According to them, the granite, which surmounts every other rock, also dips under every other rock; and is the most ancient of any that has yet been discovered in the place assigned it by nature. The central ridges of most of the mountain chains are composed of it; slaty rocks, such as clay slate, granular quartz, (*gres*,) and mica slate, rest upon its sides and form lateral chains; granular, foliated limestone, or marble, and other calcarious rocks that do not contain shells, rest upon the slate, forming the exterior ranges, and are the last formations by which this ancient uninhabited sea seems to have prepared itself for the production of its beds of shells.*†

On all occasions, even in districts that lie at a distance from the great mountain chains, where the more recent strata have been digged through, and the external covering of the earth penetrated to a considerable depth, nearly the same order of stratification has been found as that already described. The crystallized marbles never cover

* See Pallas, in his Memoir on the Formation of Mountains.
† Note B.

the shelly strata; the granite in mass never rests upon the crystallized marble, except in a few places where it seems to have been formed of granites of newer epochs. In one word, the foregoing arrangement appears to be general, and must therefore depend upon general causes, which have on all occasions exerted the same influence from one extremity of the earth to the other.*

Hence, it is impossible to deny, that the waters of the sea have formerly, and for a long time, covered those masses of matter which now constitute our highest mountains; and farther, that these waters, during a long time, did not support any living bodies. Thus, it has not been only since the commencement of animal life that these numerous changes and revolutions have taken place in the constitution of the external covering of our globe: For the masses formed previous to that event have suffered changes, as well as those which have been formed since; they have also suffered violent changes in their positions, and a part of these assuredly took place while they existed alone, and before they were covered over by the shelly masses. The proof of this lies in the overturnings, the disruptions, and the fissures which are observable in their strata, as well as in those of more recent formation, which are there even in greater number and better defined.

---

* Note C.

But these primitive masses have also suffered other revolutions, posterior to the formation of the secondary strata, and have perhaps given rise to, or at least have partaken of, some portion of the revolutions and changes which these latter strata have experienced. There are actually considerable portions of the primitive strata uncovered, although placed in lower situations than many of the secondary strata; and we cannot conceive how it should have so happened, unless the primitive strata, in these places, had forced themselves into view, after the formation of those which are secondary. In some countries, we find numerous and prodigiously large blocks of primitive substances scattered over the surface of the secondary strata, and separated by deep valleys from the peaks or ridges whence these blocks must have been derived. It is necessary, therefore, either that these blocks must have been thrown into those situations by means of eruptions, or that the valleys, which otherwise must have stopped their course, did not exist at the time of their being transported to their present sites.*†

Thus we have a collection of facts, a series of epochs anterior to the present time, and of which the successive steps may be ascertained with per-

* The scientific journeys of Saussure and Deluc give a prodigious number of instances of this nature.

† Note D.

fect certainty, although the periods which intervened cannot be determined with any degree of precision. These epochs form so many fixed points, answering as rules for directing our inquiries respecting this ancient chronology of the earth.

§ 8. *Examination of the Causes which act at present on the Surface of our Globe.*

We now propose to examine those changes which still take place on our globe, investigating the causes which continue to operate on its surface, and endeavouring to determine the extent of those effects which they are capable of producing. This portion of the history of the earth is so much the more important, as it has been long considered possible to explain the more ancient revolutions on its surface by means of these still existing causes; in the same manner as it is found easy to explain past events in political history, by an acquaintance with the passions and intrigues of the present day. But we shall presently see that unfortunately this is not the case in physical history; the thread of operation is here broken, the march of nature is changed, and none of the agents that she now employs were sufficient for the production of her ancient works.

There still exist, however, four causes in full activity, which contribute to make alterations in the

surface of our earth. These are rains and thaws, which waste down the steep mountains, and occasion their fragments to collect at their bottoms; streams of water, which sweep away these fragments, and afterwards deposit them in places where their current is abated; the sea which undermines the foundations of elevated coasts, forming steep cliffs in their places, and which throws up hillocks of sand upon flat coasts; and, finally, volcanoes, which pierce through the most solid strata from below, and either elevate or scatter abroad the vast quantity of matter which they eject.

§ 9. *Of Slips, or Falling Down of the Materials of Mountains.*

In every place where broken strata present their edges to the day in abrupt crags, fragments of their materials fall down every spring, and after every storm; these become rounded by rolling upon each other, and their collected heaps assume a determinate inclination or external form, regulated by the laws of cohesion, forming at the bottom of the crag, whence they have fallen, taluses of greater or lesser elevation, in proportion to the quantity of the fragments. These taluses constitute the sides of the valleys in all elevated mountainous regions, and are covered over by abundant vegetation, whenever these fallings-down of materials from higher mountains become less frequent; but

their want of solidity subjects them also to slips, in consequence of being undermined by the waters of rivulets. On these occasions, towns and rich populous districts are sometimes buried under the ruins of a mountain; the courses of rivers are stopped up, and lakes are formed in places which were before the abodes of fertility and cheerfulness. Fortunately such great slips occur but seldom; and the principal use of these hills, composed of fragments and ruins of the high mountains, is to furnish materials for the ravages of the torrents to operate upon.*

§ 10. *Of Alluvial Formations.*†

The rains which fall upon the ridges and summits of the mountains, the vapours which are condensed there, and the snow which is melted, descend by an infinite number of rills along their slopes, carrying off some portions of the materials of which these ridges and summits are composed, and marking their courses by numerous gutters. In their progress downwards, these small rills soon unite in the deeper furrows with which the surface of all mountains is ploughed up, run off through the deep valleys which intersect the bottoms of the mountains, and at length form the streams and rivers which restore to the sea the waters that it had formerly supplied to the atmosphere.

* Note E. † Note F.

When the snow melts, or when a storm takes place, these mountain torrents become suddenly swelled, and rush down the declivities with a violence and rapidity proportioned to their steepness: They dash against the feet of these taluses of fallen fragments which form the sides of all the elevated valleys, carrying along with them the rounded fragments of which they are composed, which become smoothed and still farther polished by rubbing on each other. But, in proportion as the swollen torrents reach the more level valleys, and the force of their current is diminished, or when they arrive at more expanded basins which allow their waters to spread out, they then throw out on their banks the largest of these stones which they had rolled down: The smaller fragments are deposited still lower; and, in general, nothing reaches the great canal of the river except the minutest fragments, or the impalpable particles, which afterwards subside to form mud. It often happens also, before these streams unite to form great rivers, that they have to pass through large and deep lakes, where they deposit the mud brought down from the mountains, and whence their waters flow out quite limpid.

The rivers in lower levels, and all the streams which take their rise in the lower mountains or hills, produce effects on the grounds through which they flow, more or less analogous to those of the torrents from the higher mountains. When swelled

by great rains, they undermine the bottoms of the earthy or sandy hills which lie in their way, and carry their fragments to be deposited on the lower grounds which they inundate, and which are somewhat raised in height by each successive inundation. Finally, when these rivers reach the great lakes, or the sea, and when of course that rapid motion by which they are enabled to keep the particles of mud in suspension has wholly ceased, these particles are deposited at each side of their mouths, where they form low grounds, by which the coasts or banks of the river are gradually lengthened out into the sea or lake. And if these new coasts are so situated that the sea also throws up sand to contribute towards their increase, provinces, and even entire kingdoms, are thus as it were created, which usually become the richest and most fertile regions, if their rulers permit human industry to exert itself in peace.

§ 11. *Of the Formation of Downs.**

The effects produced by the sea alone, without the aid of rivers, are far less beneficial. When the sea coast is low, and the bottom consists of sand, the waves push this sand towards the shore, where, at every reflux of the tide, it becomes partially dried; and the winds, which almost always blow from the sea, drift up some portion of it upon

---

* Note G.

the beach. By this means, *downs*, or ranges of low sand-hills, are formed along the coast. These, if not fixed by the growth of suitable plants, either disseminated by nature, or propagated by human industry, would be gradually, but certainly, carried towards the interior, covering up the fertile plains with their sterile particles, and rendering them unfit for the habitation of mankind; because the same winds which carried the loose dry sand from the shore to form the downs, would necessarily continue to drift that which is at the summit farther towards the land.

§ 12. *Of the Formation of Cliffs, or steep Shores.*

On the other hand, when the original coast happens to be high, so that the sea is unable to cast up any thing upon it, a gradual, but destructive operation is carried on in a different way. The incessant agitation of the waves wears it away at the bottom, and at length succeeds in undermining it, causing the upper materials to slide and tumble down, and converting the whole elevation into steep sloping bluffs or cliffs. In the progress of this change, the more elevated materials which tumble down into the sea, have their softer parts washed out and carried away by the waves; while the harder parts, continually rolled about in the agitated water, form vast collections of rounded stones and pebbles, and of sand of various degrees of fineness, which at length accumulate into sloping banks

or flat beaches, and protect the bottoms of the cliffs against farther depredations.

Such are the ordinary actions of water upon the solid land, which almost entirely consist in reducing it to lower levels, but not indefinitely. The fragments of the great mountain ridges are carried down into the valleys, while their finer particles and those of the lower hills and plains are floated to the sea. Alluvial depositions extend the coast at the expense of the interior hills, which last effect is most limited in its extent by means of vegetation. All these changes necessarily suppose the previous existence of mountains, valleys, and plains, and consequently the same causes could not have given rise to these inequalities on the surface of our globe.

The formation of downs is the most limited of all these phenomena, both in regard to height and horizontal extent, and has no manner of relation whatever to those enormous masses, the origin of which forms the peculiar object of geological research.*

§ 13. *Of Depositions formed in Water.*

Although we cannot obtain a precise knowledge of the actions exerted by water within its own bosom, still it may be ascertained in a certain degree.

* Note H.

Lakes, low meadows, marshes, and sea-ports, into which rivulets discharge their waters, more especially when these descend from near and steep hills, are continually receiving depositions of mud, which would at length fill them up entirely, if they were not carefully cleaned out. The sea is constantly accumulating quantities of sand and slime into its bays and harbours, or wherever its waters happen to become more quiet than ordinary. The currents also occasioned by the tides, are continually washing large quantities of sand from the bottom of the sea, which they collect together and heap up on various parts of the coast, forming banks and flat shallows.

§ 14. *Of Stalactites.*

Certain waters, after dissolving calcarious substances by means of the superabundant carbonic acid with which they are impregnated, allow these substances to crystallize, in consequence of the escape of the acid, and in this way form stalactites and other concretions. There are some strata, confusedly crystallized in fresh water, which are sufficiently extensive to be compared with other strata that have been left by the ancient sea.

§ 15. *Of Lithophites.*

In the torrid zone, where lithophites of many kinds abound, and are propagated with great ra-

pidity, their stony tree-like fabrics are intertwined and accumulated into the form of rocks and reefs, and, rising even to the surface of the water, shut up the entrance of harbours, and lay frightful snares for navigators. The sea, throwing up sand and mud on the tops of these rocky shelves, sometimes raises them above its own proper level, and forms islands of them, which are soon covered with a rich vegetation.

§ 16. *Of Incrustations.*

It is also possible that the animals inhabiting shells may leave their stony coverings when they die in some particular places; and that these, cemented together by slime of greater or less consistence, or by some other means, may form extensive banks of shells. But we have no evidence that the sea has now the power of agglutinating these shells by such a compact paste, or indurated cement, as that found in marbles and calcarious sand-stones, or even in the coarse limestone strata in which shells are found enveloped. Still less do we now find the sea making any depositions at all of the more solid and silicious strata which have preceded the formation of the strata containing shells. In short, all these causes would not, though combined, form a single stratum of any kind, nor produce the smallest hillock, nor alter in any perceptible degree the ordinary level of the ocean.

It has been asserted that the sea is subject to a continual diminution in its level, and proofs of this are said to have been discovered in some parts of the shores of the Baltic. Whatever may have been the cause of these appearances, we certainly know that nothing of the kind has been observed upon our coasts; and, consequently, that there has been no general lowering of the waters of the ocean. The most ancient sea-ports still have their quays and other erections at the same height above the level of the sea as at their first construction.

Certain general movements have been supposed in the sea from east to west, or in other directions; but no where has any person been able to ascertain their effects with the least degree of precision.

§ 17. *Of Volcanoes.*

The operation of volcanoes is still more limited and local than that of any of the agents which have yet been mentioned. Although we have no idea of the means employed by nature for feeding these enormous fires from such vast depths, we can judge decidedly, by their effects, of the changes which they were capable of producing upon the surface of the earth. When a volcano announces itself after some shocks of an earthquake, it forms for itself an opening. Stones and ashes are thrown to a great distance, and lava is vomited forth. The more fluid part of the lava runs in long streams,

while the less fluid portion stops at the edge of the opening, raises it all round, and forms a cone terminated by a crater. Thus volcanoes accumulate substances on the surface that were formerly buried deep in the bowels of the earth, after having changed or modified their nature or appearances, and raise them into mountains. By these means, they have formerly covered some parts of the continents, and have suddenly produced mountains in the middle of the sea. But these mountains and islands have always been composed of lava, and the whole of their materials have undergone the action of fire. Volcanoes have never raised up nor overturned the strata through which their apertures pass, and have in no degree contributed to the elevation of the great mountains which are not volcanic.

Thus we shall seek in vain among the various forces which still operate on the surface of our earth, for causes competent to the production of those revolutions and catastrophes of which its external crust exhibits so many traces: And if we have recourse to the constant external causes with which we have been hitherto acquainted, we shall have no greater success.

§ 18. *Of Astronomical Causes of the Revolutions on the Surface of the Earth.*

The pole of the earth moves in a circle round the pole of the ecliptic, and its axis is more or less inclined to the plane of the ecliptic; but these two motions, the causes of which are now ascertained, are confined within certain bounds, and are much too limited for the production of those effects which we have stated. Besides, as these motions are exceedingly slow, they are altogether inadequate to account for catastrophes which must necessarily have been sudden.

The same reasoning applies to all other slow motions which have been conceived as causes of the revolutions on the surface of our earth, chosen doubtless in the hope that their existence could not be denied, as it might always be asserted that their extreme slowness rendered them imperceptible. But it is of no importance whether these assumed slow motions be true or false, for they explain nothing, since no cause acting slowly could possibly have produced sudden effects.

Admitting that there was a gradual diminution of the waters; that the sea might take away solid matters from one place and carry them to another; that the temperature of the globe may have diminished or increased; none of these causes could

have overthrown our strata; enclosed great quadrupeds with their flesh and skin in ice; laid dry sea-shells in as perfect preservation as if just drawn up alive from the bottom of the ocean; or utterly destroyed many species, and even entire genera, of testaceous animals.

These considerations have presented themselves to most naturalists: And, among those who have endeavoured to explain the present state of the globe, hardly any one has attributed the entire changes it has undergone to slowly operating causes, and still less to causes which continue to act, as it were, under our observation. The necessity to which they were thus reduced, of seeking for causes different from those which we still observe in activity, is the very thing which has forced them to make so many extraordinary suppositions, and to lose themselves in so many erroneous and contradictory speculations, that the very name of their science, as I have elsewhere said, has become ridiculous in the opinion of prejudiced persons, who only see in it the systems which it has exploded, and forget the extensive and important series of facts which it has brought to light and established.*

* When I formerly mentioned this circumstance, of the science of geology having become ridiculous, I only expressed a well-known truth, without presuming to give my own opinion, as some respectable geologists seem to have believed. If their mistake arose from my expressions having been rather equivocal, I take this opportunity of explaining my meaning.

§ 19. *Of former Systems of Geology.*

During a long time, two events or epochs only, the Creation and the Deluge, were admitted as comprehending the changes which have occurred upon the globe; and all the efforts of geologists were directed to account for the present actual state of the earth, by arbitrarily ascribing to it a certain primitive state, afterwards changed and modified by the deluge, of which also, as to its causes, its operation, and its effects, every one of them entertained his own theory.

Thus, in the opinion of *Burnet*,* the whole earth at the first consisted of a uniform light crust, which covered over the abyss of the sea, and which, being broken for the production of the deluge, formed the mountains by its fragments. According to *Woodward*,† the deluge was occasioned by a momentary suspension of cohesion among the particles of mineral bodies; the whole mass of the globe was dissolved, and the soft paste became penetrated by shells. *Scheuchzer*‡ conceived that God raised up the mountains for the purpose of allowing the waters of the deluge to run off, and accordingly selected those portions which contained the greatest abundance of rocks, without which they

* Telluris Theoria Sacra. Lond. 1681.

† Essay towards the Natural History of the Earth. Lond. 1702.

‡ Memoires de l'Academie, 1708.

could not have supported themselves. *Whiston** fancied that the earth was created from the atmosphere of one comet, and that it was deluged by the tail of another. The heat which remained from its first origin, in his opinion, excited the whole antediluvian population, men and animals, to sin, for which they were all drowned in the deluge, excepting the fish, whose passions were apparently less violent.

It is easy to see, that though naturalists might have a range sufficiently wide within the limits prescribed by the book of Genesis, they very soon found themselves in too narrow bounds: and when they had succeeded in converting the six days employed in the work of creation into so many periods of indefinite length, their systems took a flight proportioned to the periods, which they could then dispose of at pleasure.

Even the great *Leibnitz*, as well as *Descartes*, amused his imagination by conceiving the world to be an extinguished sun, or vitrified globe; upon which the vapours condensing in proportion as it cooled, formed the seas, and afterwards deposited calcarious strata.†

By *Demaillet*, the globe was conceived to have

---

* A New Theory of the Earth. Lond. 1708.

† Leibnitz, Protogœa. *Act. Lips.* 1683; *Gott.* 1749.

been covered with water for many thousand years. He supposed that this water had gradually retired; that all the terrestrial animals were originally inhabitants of the sea; that man himself began his career as a fish: And he asserts, that it is not uncommon, even now, to meet with fishes in the ocean, which are still only half men, but whose descendants will in time become perfect human beings.*

The system of *Buffon* is merely an extension of that before devised by Leibnitz, with the addition only of a comet, which, by a violent blow upon the sun, struck off the mass of our earth in a liquefied state, along with the masses of all the other planets of our system at the same instant. From this supposition, he was enabled to assume positive dates or epochs: As, from the actual temperature of the earth, it could be calculated how long time it had taken to cool so far. And as all the other planets had come from the sun at the same time, it could also be calculated how many ages were still required for cooling the greater ones, and how far the smaller ones were already frozen.

In the present day, men of bolder imaginations than ever, have employed themselves on this great subject. Some writers have revived and greatly extended the ideas of Demaillet.

---

* Telliamed.

They suppose that every thing was originally fluid; that this universal fluid gave existence to animals, which were at first of the simplest kind, such as the monads and other infusory microscopic animalcules; that, in process of time, and by acquiring different habits, the races of these animals became complicated, and assumed that diversity of nature and character in which they now exist. It is by all those races of animals that the waters of the ocean have been gradually converted into calcarious earth; while the vegetables, concerning the origin and metamorphoses of which these authors give us no account, have converted a part of the same water into clay; and these two earths, after being stript of the peculiar characters they had received respectively from animal and vegetable life, are resolved by a final analysis into silex: Hence the more ancient mountains are more silicious than the rest. Thus, according to these authors, all the solid particles of our globe owe their existence to animal or vegetable life, and without this our globe would still have continued entirely liquid.*

Other writers have preferred the ideas of Kepler, and, like that great astronomer, have consid-

* See La Physique de Rodig. p. 106. Leipsic, 1801, and Telliamed, p. 169. Lamark has expanded this system at great length, and supported it with much sagacity, in his *Hydrogéologie*, and *Philosophie Zoologique*.

ered the globe itself as possessed of living faculties. According to them, it contains a circulating vital fluid. A process of assimilation goes on in it as well as in animated bodies. Every particle of it is alive. It possesses instinct and volition even to the most elementary of its molecules, which attract and repel each other according to sympathies and antipathies. Each kind of mineral substance is capable of converting immense masses of matter into its own peculiar nature, as we convert our aliment into flesh and blood. The mountains are the respiratory organs of the globe, and the schists its organs of secretion. By the latter it decomposes the waters of the sea in order to produce volcanic eruptions. The veins in strata are caries, or abscesses of the mineral kingdom, and the metals are products of rottenness and disease, to which it is owing that almost all of them have so bad a smell.*

It must, however, be noticed, that these are what may be termed extreme examples, and that all geologists have not permitted themselves to be carried away by such bold or extravagant conceptions as those we have just cited. Yet, among those who have proceeded with more caution, and have not searched for geological causes beyond the es-

---

* M. Patrin has used much ingenuity to establish this view of the subject, in several articles of the *Nouveau Dictionnaire d' Histoire Naturelle.*

tablished limits of physical and chemical science, there still remain much diversity and contradiction.

According to one of these writers, every thing has been successively precipitated and deposited, nearly as it exists at present; but the sea, which covered all, has gradually retired.*

Another conceives, that the materials of the mountains are incessantly wasted and floated down by the rivers, and carried to the bottom of the ocean, to be there heated under an enormous pressure, and to form strata which shall be violently lifted up at some future period, by the heat that now consolidates and hardens them.†

A third supposes the fluid materials of the globe to have been divided among a multitude of successive lakes, placed like the benches of an amphitheatre; which, after having deposited our shelly strata, have successively broken their dikes, to descend and fill the basin of the ocean.‡

According to a fourth, tides of seven or eight hundred fathoms have carried off from time to

---

* In his Geology, Delematherie assumes crystallization as the chief cause or agent.

† Hutton, and Playfair in his Illustrations of the Huttonian Theory of the Earth. *Edinb.* 1802.

‡ See Lamanon, in various parts of the Journal de Physique.

time the bottom of the ocean, throwing it up in mountains and hills on the primitive valleys and plains of the continent.*

A fifth conceives the various fragments of which the surface of the earth is composed to have fallen successively from heaven, in the manner of meteoric stones, and alleges that they still retain the marks of their origin in the unknown species of animals whose exuviæ they contain.†

By a sixth, the globe is supposed to be hollow, and to contain in its cavity a nucleus of loadstone, which is dragged from one pole of the earth to the other by the attraction of comets, changing the centre of gravity, and consequently hurrying the great body of the ocean along with it, so as alternately to drown the two hemispheres.‡

§ 20. *Diversities of the Geological Systems, and their causes.*

We might have cited twenty other systems, as different from one another as these just now enumerated. And, to prevent mistake, we wish it to be distinctly understood, that it is by no means

---

* Dolomieu, in the Journal de Physique.

† M. M. de Marschall, in Researches respecting the Origin and Developement of the present State of the Earth. *Geissen*, 1802.

‡ Bertrand, Periodical Renewal of the Terrestrial Continents. *Hamburgh*, 1799.

our intention to criticise their authors; on the contrary, we are ready to admit that these systems have generally been conceived by men of science and genius, none of whom were ignorant of the facts on which they reasoned, and several of whom had made extensive journeys for the purpose of examining them.

Whence comes it then, that there should be so much contrariety in the solutions of the same problem, that are given by men who proceed upon the same principles? This may have been occasioned by the conditions of the problem never having been all taken into consideration; by which it has remained hitherto indeterminate, and susceptible of many solutions—all equally good, when such or such conditions are abstracted; and all equally bad, when a new condition comes to be known, or when the attention is directed to some known condition, which had been formerly neglected.

§ 21. *Statement of the Nature and Conditions of the Problem to be solved.*

To quit the language of mathematics, it may be asserted, that almost all the authors of these systems, confining their attention to certain difficulties by which they were struck more forcibly than by others, have endeavoured to solve these in a way more or less probable, and have allowed others to remain unnoticed, equally numerous and equally important. For example, the only diffi-

culty with one consisted in explaining the change which had taken place on the level of the seas; with another it consisted in accounting for the solution of all terrestrial substances in the same fluid; and with a third, it consisted in showing how animals that were natives of the torrid could live under the frigid zone. Exhausting the whole of their ingenuity on these questions, they conceived that they had done every thing that was necessary, when they had contrived some method of answering them; and yet, while they neglected all the other phenomena, they did not always think of determining with precision the measure and extent of those which they attempted to explain. This is peculiarly the case in regard to the secondary stratifications, which constitute, however, the most difficult and most important portion of the problem. It has hardly ever been attempted carefully to ascertain the superpositions of their strata, or the connexions of these strata with the species of animals and of plants whose remains they enclose.

Are there certain animals and plants peculiar to certain strata, and not found in others? What are the species that appear first in order, and those which succeed? Do these two kinds of species ever accompany one another? Are there alterations in their appearances; or, in other words, does the first species appear a second time, and does the second species then disappear? Have these ani-

mals and plants lived in the places where their exuviæ are found, or have they been brought there from other places? Do all these animals and plants still continue to live in some part of the earth, or have they been totally or partially destroyed? Is there any constant connexion between the antiquity of the strata, and the resemblance or non-resemblance of the extraneous fossils, to the animals and plants that still exist? Is there any connexion, in regard to climate, between the extraneous fossils and the still living organized bodies which most nearly resemble them? May it be concluded, that the transportation of these living organized bodies, if such a thing ever happened, has taken place from north to south, or from east to west; or was it effected by means that irregularly scattered and mingled them together? And, finally, is it still possible to distinguish the epochs of these transportations, by attentively examining the strata which enclose the remains, or are imprinted by their forms?

If, from the want of sufficient evidence, these questions cannot be satisfactorily answered, how shall we be able to explain the causes of the presently existing state of our globe? It is certain, that so far from any of these points being as yet completely established, naturalists seem to have scarcely any idea of the propriety of investigating facts before they construct their systems. The cause of this strange procedure may be discovered,

by considering that all geologists hitherto have either been mere cabinet naturalists, who had themselves hardly paid any attention to the structure of mountains, or mere mineralogists, who had not studied in sufficient detail the innumerable diversity of animals, and the almost infinite complication of their various parts and organs. The former of these have only constructed systems; while the latter have made excellent collections of observations, and have laid the foundations of true geological science, but have been unable to raise and complete the edifice.

§ 22. *Of the Progress of Mineral Geology.*

The purely mineralogical portion of the great problem of the Theory of the Earth has been investigated with admirable care by Saussure, and has been since explained in an astonishing degree by Werner, and by the numerous enlightened pupils of his school.

The former of these celebrated philosophers, by a laborious investigation of the most inaccessible mountain districts during twenty years of continual research, in which he examined the Alps on all sides, and penetrated through all their defiles, has laid open to our view the entire disorder of the primitive formations, and has clearly traced the boundaries by which they are distinguishable from the secondary formations. The other equally ce-

lebrated geologist, taking advantage of the numerous excavations in the most ancient mining district in the world, has fixed the laws which regulate the succession of strata, pointing out their respective antiquity in regard to each other, and tracing each of them through all its changes and metamorphoses. From him alone we date the commencement of real geology, so far as respects the mineral natures of the strata: But neither he nor Saussure has defined the species of organized extraneous fossils in each description of the strata with that accuracy which has become necessary, now that the number of animals already known has become so great.

Other naturalists, it is true, have studied the fossil remains of organized bodies; they have collected and represented them by thousands, and their works certainly will serve as a valuable storehouse of materials. But, considering these fossil plants and animals merely in themselves, instead of viewing them in their connexion with the theory of the earth; or regarding their netrifactions and extraneous fossils as mere curiosities, rather than as historical documents; or confining themselves to partial explanations of the particular bearings of each individual specimen; they have almost always neglected to investigate the general laws affecting their position, or the relation of the extraneous fossils with the strata in which they are found.

§ 23. *Of the Importance of Extraneous Fossils, or Petrifactions, in Geology.*

The importance of investigating the relations of extraneous fossils with the strata in which they are contained, is quite obvious. It is to them alone that we owe the commencement even of the Theory of the Earth; as, but for them, we could never have even suspected that there had existed any successive epochs in the formation of our earth, and a series of different and consecutive operations in reducing it to its present state. By them alone we are enabled to ascertain, with the utmost certainty, that our earth has not always been covered over by the same external crust; because we are thoroughly assured that the organized bodies to which these fossil remains belong, must have lived upon the surface, before they came to be buried, as they now are, at a great depth. It is only by means of analogy, that we have been enabled to extend to the primitive formations, the same conclusions which are furnished directly for the secondary formations by the extraneous fossils; and if there had only existed formations or strata in which there were no extraneous fossils, it could never have been asserted that these several formations had not been simultaneous.

It is also owing to these extraneous fossils, slight as is the knowledge we have hitherto acquired

respecting them, that we have been enabled to discover the little that we yet know concerning the revolutions of our globe. From them we have learned that the strata, or at least those which contain their remains, have been quietly deposited in a fluid; that the variations of the several strata must have corresponded with the variations in the nature of the fluid; that they have been left bare by the transportation of this fluid to some other place; and that this fact must have happened more than once. Nothing of all this could have been known with certainty, without the aid of extraneous fossils.

The study of the mineralogical part of geology, though not less necessary, and even a great deal more useful to the practical arts, is yet much less instructive so far as respects the objects of our present inquiry. We remain in utter ignorance respecting the causes which have given rise to the variety in the mineral substances of which strata are composed. We are ignorant even of the agents which may have held some of these substances in a state of solution; and it is still disputed respecting several of them, whether they have owed their origin to the agency of water or fire. After all, philosophers are only agreed on one point, which is, that the sea has changed its place; and this could never have been certainly known, but for the existence of extraneous fossils. These fossils, then, which have given rise to the theory

of the earth, have at the same time furnished its principal illustrations—the only ones, indeed, that have as yet been generally received and acknowledged.*

This is the consideration by which I have been encouraged to investigate the subject of extraneous fossils. But the field is extensive; and it is only a very inconsiderable portion of it that can be cultivated by the labour of a single individual. It was necessary, therefore, to select a particular department, and I very soon made my choice. That class of extraneous fossils, which forms the peculiar subject of this Essay, engaged my attention at the very outset, because it is evidently the most fertile in affording precise results, yet at the same time less known than others, and richer in new objects of research.†‡

§ 24. *High Importance of investigating the Fossil Remains of Quadrupeds.*

It is obvious that the fossil remains of the bones of quadrupeds must lead to more rigorous conclusions than any other remains of organized bodies, and that for several reasons.

* Note K.

† My work on this subject will clearly show how far this inquiry is yet new, notwithstanding the excellent labours of Camper, Pallas, Blumenbach, Merk, Sœmmerring, Rosenmuller, Fischer, Faujas, and other learned men, whose works I have most scrupulously cited in such of my chapters as their researches are connected with.

‡ Note L.

In the first place, they indicate much more clearly the nature of the revolutions to which they have been subjected. The remains of shells certainly indicate that the sea has once existed in the places where these collections have been formed: But the changes which have taken place in their species, when rigorously inquired into, may possibly have been occasioned by slight changes in the nature of the fluid in which they were formed, or only in its temperature, and may even have arisen from other accidental causes. We can never be perfectly assured that certain species, and even genera, inhabiting the bottom of the sea, and occupying certain fixed spaces for a longer or shorter time, may not have been driven away from these by other species or genera.

In regard to quadrupeds, on the contrary, every thing is precise. The appearance of their bones in strata, and still more of their entire carcasses, clearly establishes that the bed in which they are found must have been previously laid dry, or at least that dry land must have existed in its immediate neighbourhood. Their disappearance as certainly announces that this stratum must have been inundated, or that the dry land had ceased to exist in that state. It is from them, therefore, that we learn with perfect certainty the important fact of the repeated irruptions of the sea upon the land, which the extraneous fossils and other productions of marine origin could not of themselves have

proved; and, by a careful investigation of them, we may hope to ascertain the number and the epochs of those irruptions of the sea.

Secondly, the nature of the revolutions which have changed the surface of our earth, must have exerted a more powerful action upon terrestrial quadrupeds than upon marine animals. As these revolutions have consisted chiefly in changes of the bed of the sea, and as the waters must have destroyed all the quadrupeds which they reached, if their irruption over the land was general, they must have destroyed the entire class, or, if confined only to certain continents at one time, they must have destroyed at least all the species inhabiting these continents, without having the same effect upon the marine animals. On the other hand, millions of aquatic animals may have been left quite dry, or buried in newly-formed strata, or thrown violently on the coasts, while their races may have been still preserved in more peaceful parts of the sea, whence they might again propagate and spread after the agitation of the water had ceased.

Thirdly, this more complete action is also more easily ascertained and demonstrated; because, as the number of terrestrial quadrupeds is limited, and as most of their species, at least the large ones, are well known, we can more easily determine whether fossil bones belong to a species which still

exists, or to one that is now lost. As, on the other hand, we are still very far from being acquainted with all the testaceous animals and fishes belonging to the sea, and as we probably still remain ignorant of the greater part of those which live in the extensive deeps of the ocean, it is impossible to know, with any certainty, whether a species found in a fossil state may not still exist somewhere alive. Hence some naturalists persist in giving the name of oceanic or pelagic shells to *belemnites* and *cornua-ammonis*, and some other genera, which have not hitherto been found, except in the fossil state, in ancient strata; meaning by this, that although these have not as yet been found in a living or recent state, it is because they inhabit the bottom of the ocean, far beyond the reach of our nets.

§ 25. *Of the small Probability of discovering new Species of the larger Quadrupeds.*

Naturalists certainly have neither explored all the continents, nor do they as yet know even all the quadrupeds of those parts which have been explored. New species of this class are discovered from time to time; and those who have not examined with attention all the circumstances belonging to these discoveries, may allege also, that the unknown quadrupeds, whose fossil bones have been found in the strata of the earth, have hitherto remained concealed in some islands not yet discovered by navigators, or in some of the vast de-

serts which occupy the middle of Africa, Asia, the two Americas, and New Holland. But, if we carefully attend to the kinds of quadrupeds that have been recently discovered, and to the circumstances of their discovery, we shall easily perceive that there is very little chance indeed of our ever finding alive those which have only been seen in a fossil state.

Islands of moderate size, and at a considerable distance from the large continents, have very few quadrupeds, and these mostly very small. When they contain any of the larger quadrupeds, these must have been carried to them from other countries. Cook and Bougainville found no other quadrupeds besides hogs and dogs in the South Sea islands; and the largest quadruped of the West India islands, when first discovered, was the *agouti*, a species of the *cavy*, an animal apparently between the rat and the rabbit.

It is true, that the great continents, as Asia, Africa, the two Americas, and New Holland, have large quadrupeds, and, generally speaking, contain species proper to each: Insomuch, that, upon discovering countries which are isolated from the rest of the world, the animals they contain of the class of quadrupeds were found entirely different from those which existed in other countries. Thus, when the Spaniards first penetrated into South America, they did not find it to contain a single

quadruped exactly the same with those of Europe, Asia, and Africa. The puma, the jaguar, the tapir, the capybara, the lama, or glama, and vicugna, and the whole tribe of sapajous, were to them entirely new animals, of which they had not the smallest idea.

Similar circumstances have recurred in our own time, when the coasts of New Holland and the adjacent islands were first examined. The species of the kangaroo, *phascoloma*, *dasyurus*, *peramela*, *phalanger*, or flying opposum, with the hairy and spinous duck-billed animals denominated *ornithorinchus* and *echidna*,* have astonished zoologists by presenting new and strange conformations, contrary to all former rules, and incapable of being reduced under any of the former systems.

If there still remained any great continent to be discovered, we might perhaps expect to be made acquainted with new species of large quadrupeds; among which some might be found more or less similar to those of which we find the exuviæ in the bowels of the earth. But it is merely sufficient to glance the eye over the map of the world, and observe the innumerable directions in which navigators have traversed the ocean, in order to be satis-

---

* These are new animals of Australasia, or New Holland, only recently discovered, whose strange conformations, not analogous with the animals of the old world, or of America, have required the adoption of new generic terms by Cuvier and other naturalists.—*Transl.*

fied that there does not remain any large land to be discovered, unless it may be situated towards the antartic pole, where eternal ice necessarily forbids the existence of animal life.

Hence it is only from the interiors of the large divisions of the world already known, that we can now hope to procure any quadrupeds hitherto unknown. But a very little reflection will be sufficient to convince us, that our hopes from thence are not much better founded than from the larger islands.

Doubtless, European travellers cannot easily penetrate through vast extents of countries which are either uninhabited, or peopled only with ferocious tribes; and this is peculiarly the case in regard to Africa. But there is nothing to prevent the animals themselves from roaming in all directions, and penetrating to the coasts. Even although great chains of mountains may intervene between the coasts and the interior deserts, these must certainly be broken in some parts, to allow the rivers to pass through; and in these burning deserts the animals naturally follow the courses of rivers. The inhabitants of the coasts must also frequently penetrate inland along the rivers, and will quickly acquire a knowledge of all the remarkable living creatures, even to the very sources of these rivers, either from personal observation, or by intercourse with the inhabitants of the interior. At no period of our history, therefore, could

civilized nations frequent the coasts of large countries for any length of time, without gaining some tolerable knowledge of all the animals they contained, or at least of such as were any way remarkable for their size or configuration. This reasoning is supported by well known facts. Thus, although the ancients seem never to have passed the mountains of Imaus, or to have crossed the Ganges towards the east of Asia, and never penetrated far to the south of Mount Atlas in Africa, yet they were acquainted with all the larger animals of these two grand divisions of the world; and if they have not distinguished all their species, it was because the similarities of some of these occasioned them to be confounded together, and not because they had not seen them, or heard them talked of by others.

The ancients were perfectly acquainted with the elephant, and the history of that quadruped is given more exactly by Aristotle than by Buffon. They were not ignorant even of the differences which distinguish the elephants of Africa from those of Asia.*

They knew the two-horned rhinoceros, which Domitian exhibited in his shows at Rome, and had stamped on his medals, and of which Pausanias has left a very good description. Even the one-

* See this more particularly noticed in the history of the elephant, in the second volume of my Researches into the Extraneous or Fossil Remains of Quadrupeds.

horned rhinoceros, although its country be far from Rome, was equally known to the Romans; Pompey showed them one in the circus, and Strabo has described another which he saw at Alexandria.*

The hippopotamus has not been so well described by the ancients as the two foregoing animals; yet very exact representations of it have been left by the Romans in their monuments relative to Egypt, such as the statue of the Nile, the Prenestine pavement, and a great number of medals. It is known that this animal was frequently shown to the Romans, having been exhibited in the circus by Scaurus, Augustus, Antoninus, Commodus, Heliogabalus, Philip†, and Carinus‡.

The two species of camel, the Bactrian and Arabian, were both well known to the ancients, and are very well described and characterized by Aristotle.§

The giraffe, or camelopardalis, was likewise known to the ancients, one having been shown alive in the circus during the dictatorship of Julius Cæsar, in the year of Rome 708. Ten of them were shown at once by Gordian III., all of which

* See the history of the Rhinoceros in my second volume.

† See the history of the Hippopotamus, in my second volume.

‡ Calphurnii, Ecl. VI. 66.

§ Hist. Anim. lib. II. cap. I.

were slain at the secular games of the emperor Philip.*

When we read with attention the descriptions given of the hippopotamus by Herodotus and Aristotle, which are supposed to have been borrowed from Hecatæus of Miletus, we cannot fail to perceive that these must have been taken from two very different animals; one of which is the true hippopotamus, and the other the gnou, or *antelope gnu* of Gmelin's edition of the Systema Naturæ.

The *aper æthiopicus* of Agatharcides, which he describes as having horns, is precisely the Ethiopian hog, or *engallo*, of Buffon and other modern naturalists, whose enormous tusks deserve the name of horns, almost as much as those of the elephant.†

The *bubalus* and the *nagor* are described by Pliny: the *gazella* by Elian; the *oryx* by Oppian; and the *axis*, so early as the time of Ctesias: all of them species of the antelope genus.

Elian gives a very good description of the *bos grunniens*, or grunting ox, under the name of the ox having a tail which serves for a fly-flapper.‡

---

* Jul. Capitol. Gord. III. cap. 23.
† Ælian. Anim. V. 27.
‡ Id. XV. 14.

The buffalo was not domesticated by the ancients; but the *bos Indicus*, or Indian ox of Elian,* having horns sufficiently large to contain three amphoræ, was assuredly that variety of the buffalo which is now called the *arnee.*

The ancients were acquainted with hornless oxen,† and with that African variety of the ox whose horns are only fastened to the skin,‡ and hang down dangling at the sides of the head. They also knew those oxen of India which could run as swift as horses,§ and those which are so small as not to exceed the size of a he-goat.|| Sheep also with broad tails were not unknown to them,¶ and those other Indian sheep which were as large as asses.**

Although the accounts left us by the ancients respecting the *urus*, or *aurochs*, the rein-deer, and the elk, are all mingled with fable, they are yet sufficient to prove that these animals were not unknown to them, but that the reports which had reached them had been communicated by ignorant or barbarous people, and had not been corrected by the actual observations of men of learning.

---

* Ælian. Anim. III. 34.
† Id. II. 53.
‡ Id. II. 20.
§ Id. XV. 24.
|| Id. ibid.
¶ Id. III. 3.
** Id. IV. 32.

Even the white bear had been seen in Egypt while under the Ptolemies.*

Lions and panthers were quite common at Rome, where they were presented by hundreds in the games of the circus. Even tigers had been seen there, together with the striped hyena, and the nilotic crocodile. There are still preserved in Rome some ancient mosaic, or tesselated pavements, containing excellent delineations of the rarest of these animals; among which a striped hyena is very perfectly represented in a fragment of mosaic in the Vatican museum. While I was at Rome, a tesselated pavement, composed of natural stones, arranged in the Florentine manner, was discovered in a garden beside the triumphal arch of Galienus, which represented four Bengal tigers in a most admirable manner.

The museum of the Vatican has the figure of a crocodile in basalt, almost perfectly represented, except that it has one claw too many on the hind feet. Augustus at one time presented thirty-six of these animals to the view of the people.†

It is hardly to be doubted that the *hippotigris* was the zebra, which is now only found in the southern

---

* Athenæis, lib. V. † Dion. lib. LV.

parts of Africa.* Caracalla killed one of these in the circus.

It might easily be shown also that almost all the most remarkable species of the *simiæ* of the old world have been distinctly indicated by ancient writers under the names of *pitheci*, *sphinges*, *satyri*, *cephi*, *cynocephali*, or *cercopitheci*.†

They also knew and have described several very small species of *gnawers*,‡ especially such of that order as possessed any peculiar conformation or remarkable quality; as we find, for instance, the *jerboa* represented upon the medals of Cyrene, and indicated under the name of *mus bipes*, or two-legged rat. But the smaller species are not of much importance in regard to the object before us, and it is quite sufficient for the inquiry in which we are engaged, to have shown that all the larger species of quadrupeds, which possess any peculiar or remarkable character, and which we know to inhabit Europe, Asia, and Africa, at the present day, were known to the ancients; whence we may fairly conclude, that their silence in respect to the small

* Id. LXXVII. Compare also Gisb. Cuperi de Eleph. in nummis obviis. ex. II cap. 7.

† See Lichtenstein, Comment. de Simiarum quotquot veteribus innotuerunt formis. *Hamburg*, 1791.

‡ Cuvier gives this name, *rongeurs*, here translated *gnawers*, to the order denominated glires by Linnæus, owing to their fore-teeth being peculiarly fitted for gnawing the roots, barks, and stems of vegetables. —*Transl.*

quadrupeds, and their neglect in distinguishing the species which very nearly resemble each other, as the various species of antelopes and of some other genera, was occasioned by want of attention and ignorance of methodical arrangement, and not by any difficulties proceeding from the climates or distance of the places which these animals inhabited. We may also conclude with equal certainty, that as eighteen or twenty centuries at the least, with the advantages of circumnavigating Africa, and of penetrating into all the most distant regions of India, have added nothing in this portion of natural history to the information left us by the ancients, it is not at all probable that succeeding ages will add much to the knowledge of our posterity.

Perhaps some persons may be disposed to employ an opposite train of argument, and to allege that the ancients were not only acquainted with as many large quadrupeds as we are, as has been already shown, but that they actually described several others which we do not now know; that we are rash in considering the accounts of all such animals as fabulous; that we ought to search for them with the utmost care, before concluding that we have acquired a complete knowledge of the existing animal creation; and, in fine, that among these animals which we presume to be fabulous, we may perhaps discover, when better acquainted with them, the actual originals of the bones of those species which are now unknown. Perhaps

some may even conceive that the various monsters, essential ornaments of the history of the heroic ages of almost every nation, are precisely those very species which it was necessary to destroy, in order to allow the establishment of civilized societies. Thus Theseus and Bellerophon must have been more fortunate than all the nations of more modern days, who have only been able to drive back the noxious animals into the deserts and ill-peopled regions, but have never yet succeeded in exterminating a single species.

§ 26. *Inquiry respecting the Fabulous Animals of the Ancients.*

It is easy to reply to the foregoing objection, by examining the descriptions that are left us by the ancients of those unknown animals, and by inquiring into their origins. Now the greater number of those animals have an origin purely mythological, and of this origin the descriptions given of them bear the most unequivocal marks; as, in almost all of them, we see merely the different parts of known animals united by an unbridled imagination, and in contradiction to every established law of nature.

Those which have been invented by the poetical fancy of the Greeks, have at least some grace and elegance in their composition, resembling the fantastic decorations which are still observable on

the ruins of some ancient buildings, and which have been multiplied by the fertile genius of Raphael in his paintings. Like these, they unite forms which please the eye by agreeable contours and fanciful combinations, but which are utterly repugnant to nature and reason; being merely the productions of inventive and playful genius, or perhaps meant as emblematical representations of metaphysical or moral propositions, veiled under mystical hieroglyphics, after the oriental manner. Learned men may be permitted to employ their time and ingenuity in attempts to decipher the mystic knowledge concealed under the forms of the sphinx of Thebes, the pegasus of Thessaly, the minotaur of Crete, or the chimera of Epirus; but it would be folly to expect seriously to find such monsters in nature. We might as well endeavour to find the animals of Daniel, or the beasts of the Apocalypse, in some hitherto unexplored recesses of the globe. Neither can we look for the mythological animals of the Persians, —creatures of a still bolder imagination—such as the *martichore*, or destroyer of men, having a human head on the body of a lion, and the tail of a scorpion;* the *griffin*, or guardian of hidden treasures, half eagle and half lion;† or the *cartazonon*,

* Plin. VIII. 21.—Aristot.—Phot. Bibl. art. 72.—Ctes. Indic.—Ælian. Anim. IV. 21.

† Ælian. Anim.

or wild ass, armed with a long horn on its forehead.*

Ctesias, who reports these as actual living animals, has been looked upon by some authors as an inventor of fables; whereas he only attributes real existence to hieroglyphical representations. These strange compositions of fancy have been seen in modern times on the ruins of Persepolis.† It is probable that their hidden meanings may never be ascertained; but at all events we are quite certain that they were never intended to be representations of real animals.

Agatharcides, another fabricator of animals, drew his information in all probability from a similar source. The ancient monuments of Egypt still furnish us with numerous fantastic representations, in which the parts of different kinds of creatures are strangely combined—men with the heads of animals, and animals with the heads of men; which have given rise to cynocephali, satyrs, and sphinxes. The custom of exhibiting in the same sculpture, in bas-relief, men of very different heights, of making kings and conquerors gigantic, while their subjects and vassals are represented as only a fourth or fifth part of their size, must

---

* Id. XVI. 20.—Photii Bibl. art. 72.—Ctes. Indic.

† Le Brun. Voy. to Muscovy, Persia, and India, vol. II. See also the German work by M. Heeren, on the Commerce of the Ancients.

have given rise to the fable of the pigmies. In some corner of these monuments, Agatharcides must have discovered his carnivorous bull, whose mouth, extending from ear to ear, devoured every other animal that came in his way.* But no naturalist scarcely will acknowledge the existence of any such animal, since nature has never joined cloven hoofs and horns with teeth adapted for cutting and devouring animal food.

There may have been many other figures equally strange with these, either among those monuments of Egypt which have not been able to resist the ravages of time, or in the ancient temples of Ethiopia and Arabia, which have been destroyed by the religious zeal of the Abyssinians and Mahometans. The monuments of India teem with such figures; but the combinations in these are so ridiculously extravagant, that they have never imposed even upon the most credulous. Monsters with an hundred arms, and twenty heads of different kinds, are far too absurd to be believed.

Nay, the inhabitants of China and Japan have their imaginary animals, which they represent as real, and that too in their religious books. The Mexicans had them. In short, they are to be found among every people whose idolatry has not yet ac-

---

* Phot. Bibl. art. 250.—Agarthacid. Excerp. Hist. cap 39.—Ælian. Anim. XVII. 45.—Plin. VIII. 21.

quired some degree of refinement. But is there any one who could possibly pretend to discover, amidst the realities of animal nature, what are thus so plainly the productions of ignorance and superstition? And yet some travellers, influenced by a desire to make themselves famous, have gone so far as to pretend that they saw these fancied beings; or, deceived by a slight resemblance, into which they were too careless to inquire, they have identified these with creatures that actually exist. In their eyes, large baboons, or monkeys, have become *cynocéphali*, and sphinxes, real men with long tails. It is thus that St. Augustin imagined he had seen a satyr.

Real animals, observed and described with equal inaccuracy, may have given rise to some of these ideal monsters. Thus, we can have no doubt of the existence of the hyena, although the back of this animal be not supported by a single bone, and although it does not change its sex yearly, as alleged by Pliny. Perhaps the carnivorous bull may only have been the two-horned rhinoceros, falsely described. M. de Weltheim considers the auriferous ants of Herodotus as the *corsacs** of modern naturalists.

The most famous among these fabulous animals of the ancients was the *unicorn*. Its real existence

---

* The Korsake, or Corsac fox of Pallas and Pennant.—*Transl.*

has been obstinately asserted even in the present day, or at least proofs of its existence have been eagerly sought for. Three several animals are frequently mentioned by the ancients as having only one horn placed on the middle of the forehead. The *oryx* of Africa, having cloven hoofs, the hair placed reversely to that of other animals,* its height equal to that of the bull,† or even of the rhinoceros,‡ and said to resemble deer and goats in its form;§ the *Indian ass*, having solid hoofs; and the *monoceros*, properly so called, whose feet are sometimes compared to those of the lion,|| and sometimes to those of the elephant,¶ and is therefore considered as having divided feet. The horse unicorn** and the bull unicorn are doubtless both referable to the Indian ass, for even the latter is described as having solid hoofs.†† We may therefore be fully assured that these animals have never really existed, as no solitary horns have ever found their way into our collections, excepting those of the rhinoceros and narwal.

After careful consideration, it is impossible that we should give any credit to rude sketches made by savages upon rocks. Entirely ignorant of

---

* Aristot. Anim. II. 1. and III. 2.—Plin. XI. 46.

† Herodot. IV. 192.

‡ Oppian, Cyneg. II. vers. 551.

§ Plin. VIII. 53.

|| Philostrog. III. ii.

¶ Plin. VIII. 21.

** Onesecrit. ap. Strab. lib. XV.—Ælian. Anim. XIII. 42.

†† See Pliny and Solinus.

perspective, and wishing to represent the outlines of a straight horned antelope in profile, they could only give the figure one horn, and thus they produced an oryx. The oryxes, too, that are seen on the Egyptian monuments, are nothing more, probably, than productions of the stiff style, imposed on the sculptors of the country by religious prejudices. Several of their profiles of quadrupeds show only one fore and one hinder leg, and it is probable that the same rule led them also to represent only one horn. Perhaps their figures may have been copied after individuals that had lost one of their horns by accident, a circumstance that often happens to the chamois and the saiga, species of the antelope genus, and this would be quite sufficient to establish the error. All the ancients, however, have not represented the oryx as having only one horn. Oppian expressly attributes two to this animal, and Ælian mentions one that had four.* Finally, if this animal was ruminant and cloven-footed, we are quite certain that its frontal bone must have been divided longitudinally into two, and that it could not possibly, as it is very justly remarked by Camper, have had a horn placed upon the suture.

It may be asked, however, What two-horned animals could have given an idea of the *oryx*, in the forms in which it has been transmitted down to us,

---

* Ælian, Anim. XV. 14.

even independent of the notion of a single horn? To this I answer, as already done by Pallas, that it was the straight-horned *antelope oryx* of Gmelin, improperly named *pasan* by Buffon. This animal inhabits the deserts of Africa, and must frequently approach the confines of Egypt, and appears to be that which is represented in the hieroglyphics. It equals the ox in height, while the shape of its body approaches to that of a stag, and its straight horns present exceedingly formidable weapons, hard almost as iron, and sharp-pointed like javelins. Its hair is whitish; it has black spots and streaks on its face, and the hair on its back points forwards. Such is the description given by naturalists; and the fables of the Egyptian priests, which have occasioned the insertion of its figure among their hieroglyphics, do not require to have been founded in nature. Supposing that an individual of this species may have been seen which had lost one of its horns by some accident, it may have been taken as a representative of the entire race, and erroneously adopted by Aristotle to be copied by all his successors. All this is quite possible and even natural, and gives not the smallest evidence for the existence of a single-horned species of antelope.

In regard to the Indian ass, of the alexipharmic virtues of whose horn the ancients speak, we find the eastern nations of the present day attributing exactly the same properties of counteracting poison to the horn of the rhinoceros. When this horn

was first imported into Greece, nothing probably was known respecting the animal to which it belonged; and accordingly it was not known to Aristotle. Agatharcides is the first author by whom it is mentioned. In the same manner, ivory was known to the ancients long before the animal from which it is procured; and perhaps some of their travellers may have given to the rhinoceros the name of *Indian ass*, with as much propriety as the Romans denominated the elephant the *bull of Lucania*. Every thing which they relate of the strength, size, and ferocity of their wild ass of India, corresponds sufficiently with the rhinoceros. In succeeding times, when the rhinoceros came to be better known to naturalists, finding that former authors mentioned a single-horned animal under the name of Indian ass, they concluded, without any examination, that it must be quite a distinct creature, having solid hoofs. We have remaining a detailed description of the Indian ass, written by Ctesias;* but, as we have already seen that this must have been taken from the ruins of Persepolis, it should go for nothing in the real history of the animal.

When there afterwards appeared more exact descriptions of an animal having several toes or hoofs on each foot, the ancients conceived it to be a third species of one-horned animals, to which they gave the name of *monoceros*. These double,

* Ælian. Anim. IV. 32.

and even triple references, are more frequent among ancient writers, because most of their works which have come down to us were mere compilations; because even Aristotle himself has often mixed borrowed facts with those which had come under his own observation; and because the habit of critically investigating the authorities of previous writers, was as little known among ancient naturalists as among their historians.

From all these reasonings and digressions, it may be fairly concluded, that the large animals of the ancient continent with which we are now acquainted, were known to the ancients; and that all the animals of which the ancients have left descriptions, and which are now unknown, were merely fabulous. It also follows, that the large animals of the three anciently known quarters of the world, were very soon known to the people who frequented their coasts.

It may also be concluded, that no large species remain to be discovered in America, as there is no good reason that can be assigned why any such should exist in that country with which we are unacquainted, and in fact none has been discovered there during the last hundred and fifty years. The tapir, jaguar, puma, cabiai or capibara, glama, vicunna, red-wolf, buffalo, or American bison, anteaters, sloths, and armadillos, are all contained in the works of Margrave and Hernandez, as well

described as in Buffon and even better, for Buffon has mistaken and confused the natural history of the ant-eaters, has mixed the description of the jaguar with that of the red wolf, and has confounded the American bison with the aurochs, or urus, of Poland. Pennant, it is true, was the first naturalist who clearly distinguished the musk ox; but it had been long mentioned by travellers. The cloven-footed, or Chilese, horse of Molina, has not been described by any of the early Spanish travellers, but its existence is more than doubtful, and the authority of Molina is too suspicious to entitle us to believe that this animal actually exists. The Muflon of the blue mountains is the only American quadruped of any size hitherto known, of which the discovery is entirely modern; and perhaps it may only have been an *argali*, that had strayed from eastern Siberia over the ice.*

After all that has been said, it is quite impossible to conceive that the enormous *mastedontes* and gigantic *megatheria*,† whose bones have been discovered under ground in North and South America,

* The argali had long before been mentioned by writers as inhabiting Kamtschatka, the Kurili islands, and probably the north-west coast of America and California.—*Transl.*

† These are new names devised to characterize the animals of which the bones and teeth have been found in large quantities in America, both in Virginia, on the banks of the Ohio, and in Chili and Peru. —*Transl.*

can still exist alive in that quarter of the world. They could not fail to be observed by the hunting tribes, which continually wander in all directions through the wilds of America. Indeed they themselves seem to be fully aware that these animals no longer exist in their country, as they have invented a fabulous account of their destruction, alleging that they were all killed by the Great Spirit, to prevent them from extirpating the human race. It is quite obvious that this fable has been invented subsequently to the discovery of the bones; just as the inhabitants of Siberia have contrived one respecting the *mammoth*, whose bones have been found in that country, alleging that it still lives under ground like the mole: and just as the ancients had their fables about the graves of giants, who were thought to have been buried wherever the bones of elephants happened to be dug up.

From all these considerations, it may be safely concluded, as shall be more minutely explained in the sequel,—That none of the large species of quadrupeds, whose remains are now found imbedded in regular rocky strata, are at all similar to any of the known living species:—That this circumstance is by no means the mere effect of chance, or because the species to which these fossil bones have belonged are still concealed in the desert and uninhabited parts of the world, and have hitherto escaped the observation of travellers; but,—That this astonishing phenomenon has proceeded from

general causes, and that the careful investigation of it affords one of the best means for discovering and explaining the nature of these causes.

§ 27. *Of the Difficulty of distinguishing the Fossil Bones of Quadrupeds.*

While the study of the fossil remains of the greater quadrupeds is more satisfactory, by the clear results which it affords, than that of the remains of other animals found in a fossil state, it is also complicated with greater and more numerous difficulties. Fossil shells are usually found quite entire, and retaining all the characters requisite for comparing them with the specimens contained in collections of natural history, or represented in the works of naturalists. Even the skeletons of fishes are found more or less entire, so that the general forms of their bodies can, for the most part, be ascertained, and usually, at least, their generic and specific characters are determinable, as these are mostly drawn from their solid parts. In quadrupeds, on the contrary, even when their entire skeletons are found, there is great difficulty in discovering their distinguishing characters, as these are chiefly founded upon their hair and colours, and other marks which have disappeared previous to their incrustation. It is also very rare to find any fossil skeletons of quadrupeds in any degree approaching to a comple state, as the strata for the most part only contain separate bones, scattered

confusedly, and almost always broken and reduced to fragments, which are the only means left to naturalists for ascertaining the species or genera to which they have belonged.

It may be stated also, that most observers, alarmed by these formidable difficulties, have passed slightly over the fossil remains of quadrupeds, and have satisfied themselves with classing them vaguely, by means of slight resemblances, or have not even pretended to give them names. Hence this portion of the history of extraneous fossils, though the most important and most instructive, has been investigated with less care than any other.*

Fortunately, comparative anatomy, when thoroughly understood, enables us to surmount all these difficulties, as a careful application of its principles instructs us in the correspondence and dissimilarity of the forms of organized bodies of different kinds, by which each may be rigorously ascertained, from almost every fragment of its various parts and organs.

Every organized individual forms an entire sys-

---

*As I have already remarked on a former occasion, it is not my intention, by these observations, to detract from the merits of Camper, Pallas, Blumenbach, Sœmmering, Merk, Faujas, Rosenmuller, and other naturalists, in regard to extraneous fossils: But, though their observations have been of great value in my researches, and are quoted by me in every step, they are in general very incomplete.

tem of its own, all the parts of which mutually correspond, and concur to produce a certain definite purpose, by reciprocal reaction, or by combining towards the same end. Hence none of these separate parts can change their forms without a corresponding change on the other parts of the same animal, and consequently each of these parts, taken separately, indicates all the other parts to which it has belonged. Thus, as I have elsewhere shown, if the viscera of an animal are so organized as only to be fitted for the digestion of recent flesh, it is also requisite that the jaws should be so constructed as to fit them for devouring prey; the claws must be constructed for seizing and tearing it to pieces; the teeth for cutting and dividing its flesh; the entire system of the limbs, or organs of motion, for pursuing and overtaking it; and the organs of sense, for discovering it at a distance. Nature also must have endowed the brain of the animal with instincts sufficient for concealing itself, and for laying plans to catch its necessary victims.

Such are the universal conditions that are indispensable in the structure of carnivorous animals; and every individual of that description must necessarily possess them combined together, as the species could not otherwise subsist. Under this general rule, however, there are several particular modifications, depending upon the size, the manners, and the haunts of the prey for which each species of carnivorous animal is destined or

fitted by nature; and, from each of these particular modifications, there result certain differences in the more minute conformations of particular parts, all, however, conformable to the general principles of structure already mentioned. Hence it follows, that in every one of their parts we discover distinct indications, not only of the classes and orders of animals, but also of their genera, and even of their species.

In fact, in order that the jaw may be well adapted for laying hold of objects, it is necessary that its condyle should have a certain form; that the resistance, the moving power, and the fulcrum, should have a certain relative position with respect to each other; and that the temporal muscles should be of a certain size; The hollow or depression, too, in which these muscles are lodged, must have a certain depth; and the zygomatic arch under which they pass must not only have a certain degree of convexity, but it must be sufficiently strong to support the action of the masseter.

To enable the animal to carry off its prey when seized, a corresponding force is requisite in the muscles which elevate the head; and this necessarily gives rise to a determinate form of the vertebræ to which these muscles are attached, and of the occiput into which they are inserted.

In order that the teeth of a carnivorous animal may be able to cut the flesh, they require to be sharp, more or less so in proportion to the greater or less quantity of flesh that they have to cut. It is requisite that their roots should be solid and strong, in proportion to the quantity and the size of the bones which they have to break to pieces. The whole of these circumstances must necessarily influence the developement and form of all the parts which contribute to move the jaws.

To enable the claws of a carnivorous animal to seize its prey, a considerable degree of mobility is necessary in their paws and toes, and a considerable strength in the claws themselves. From these circumstances, there necessarily result certain determinate forms in all the bones of their paws, and in the distribution of the muscles and tendons by which they are moved. The fore-arm must possess a certain facility of moving in various directions, and consequently requires certain determinate forms in the bones of which it is composed. As the bones of the fore-arm are articulated with the arm-bone or humerus, no change can take place in the form and structure of the former without occasioning correspondent changes in the form of the latter. The shoulder blade also, or scapula, requires a correspondent degree of strength in all animals destined for catching prey, by which it likewise must necessarily have an appropriate form. The play and action of all these parts re-

quire certain proportions in the muscles which set them in motion, and the impressions formed by these muscles must still farther determine the forms of all these bones.

After these observations, it will be easily seen that similar conclusions may be drawn with respect to the hinder limbs of carnivorous animals, which require particular conformations to fit them for rapidity of motion in general; and that similar considerations must influence the forms and connexions of the vertebræ and other bones constituting the trunk of the body, to fit them for flexibility and readiness of motion in all directions. The bones also of the nose, of the orbit, and of the ears, require certain forms and structures to fit them for giving perfection to the senses of smell, sight, and hearing, so necessary to animals of prey. In short, the shape and structure of the teeth regulate the forms of the condyle, of the shoulder-blade, and of the claws, in the same manner as the equation of a curve regulates all its other properties; and, as in regard to any particular curve, all its properties may be ascertained by assuming each separate property as the foundation of a particular equation; in the same manner, a claw, a shoulder-blade, a condyle, a leg or arm bone, or any other bone separately considered, enables us to discover the description of teeth to which they have belonged; and so also reciprocally we may determine the forms of the other bones from the teeth. Thus,

commencing our investigation by a careful survey of any one bone by itself, a person who is sufficiently master of the laws of organic structure, may, as it were, reconstruct the whole animal to which that bone had belonged.

This principle is sufficiently evident, in its general acceptation, not to require any more minute demonstration; but when it comes to be applied in practice, there is a great number of cases in which our theoretical knowledge of these relations of forms is not sufficient to guide us, unless assisted by observation and experience.

For example, we are well aware that all hoofed animals must necessarily be herbivorous, because they are possessed of no means of seizing upon prey. It is also evident, having no other use for their fore-legs than to support their bodies, that they have no occasion for a shoulder so vigorously organized as that of carnivorous animals; owing to which, they have no clavicles or accromion processes, and their shoulder-blades are proportionally narrow. Having also no occasion to turn their fore-arms, their radius is joined by ossification to the ulna, or is at least articulated by gynglymus with the humerus. Their food, being entirely herbaceous, requires teeth with flat surfaces, on purpose to bruise the seeds and plants on which they feed. For this purpose also, these surfaces require to be unequal, and are consequently composed of

alternate perpendicular layers of hard enamel and softer bone. Teeth of this structure necessarily require horizontal motions, to enable them to triturate or grind down the herbaceous food; and, accordingly, the condyles of the jaw could not be formed into such confined joints as in the carnivorous animals, but must have a flattened form, correspondent to sockets in the temporal bones, which also are more or less flat for their reception. The hollows likewise of the temporal bones, having smaller muscles to contain, are narrower, and not so deep, &c. All these circumstances are deducible from each other, according to their greater or less generality, and in such manner that some are essentially and exclusively appropriated to hoofed quadrupeds, while other circumstances, though equally necessary to that description of animals, are not exclusively so, but may be found in animals of other descriptions, where other conditions permit or require their existence.

When we proceed to consider the different orders or subdivisions of the class of hoofed animals, and examine the modifications to which the general conditions are liable, or rather the particular conditions which are conjoined, according to the respective characters of the several subdivisions, the reasons upon which these particular conditions or rules of conformation are founded become less evident. We can easily conceive, in general, the necessity of a more complicated system of diges-

tive organs in those species which have less perfect masticatory systems; and hence we may presume that these latter animals require especially to be ruminant, which are in want of such or such kinds of teeth; and may also deduce, from the same considerations, the necessity of a certain conformation of the esophagus, and of corresponding forms in the vertebræ of the neck, &c. But I doubt whether it would have been discovered, independently of actual observation, that ruminant animals should all have cloven hoofs, and that they should be the only animals having that particular conformation; that the ruminant animals only should be provided with horns on their foreheads; that those among them which have sharp tusks, or canine teeth, should want horns, &c.

As all these relative conformations are constant and regular, we may be assured that they depend upon some sufficient cause; and, since we are not acquainted with that cause, we must here supply the defect of theory by observation, and in this way lay down empirical rules on the subject, which are almost as certain as those deduced from rational principles, especially if established upon careful and repeated observation. Hence, any one who observes merely the print of a cloven hoof, may conclude that it has been left by a ruminant animal, and regard the conclusion as equally certain with any other in physics or in morals. Consequently, this single foot-mark clearly indi-

cates to the observer the forms of the teeth, of the jaws, of the vertebræ, of all the leg-bones, thighs, shoulders, and of the trunk of the body of the animal which left the mark. It is much surer than all the marks of Zadig. Observation alone, independent entirely of general principles of philosophy, is sufficient to show that there certainly are secret reasons for all these relations of which I have been speaking.

When we have established a general system of these relative conformations of animals, we not only discover specific constancy, if the expression may be allowed, between certain forms of certain organs, and certain other forms of different organs; we can also perceive a classified constancy of conformation, and a correspondent gradation between these two sets of organs, which demonstrate their mutual influence upon each other, almost as certainly as the most perfect deduction of reason. For example, the masticatory system is generally more perfect in the non-ruminant hoofed quadrupeds than it is in the cloven-hoofed or ruminant quadrupeds; as the former possess incisive teeth, or tusks, or almost always both of these, in both jaws. The structure also of their feet is in general more complicated, having a greater number of toes, or their phalanges less enveloped in the hoof, or a greater number of distinct metacarpal and metatarsal bones, or more numerous tarsal bones, or the fibula more completely distinct from the tibia: or,

finally, that all these enumerated circumstances are often united in the same species of animal.

It is quite impossible to assign reasons for these relations; but we are certain that they are not produced by mere chance, because, whenever a cloven-hoofed animal has any resemblance in the arrangement of its teeth to the animals we now speak of, it has the resemblance to them also in the arrangement of its feet. Thus camels, which have tusks, and also two or four incisive teeth in the upper jaw, have one additional bone in the tarsus, their scaphoid and cuboid bones not being united into one; and have also very small hoofs, with corresponding phalanges, or toe-bones. The musk animals, whose tusks are remarkably conspicuous, have a distinct fibula as long as the tibia; while the other cloven-footed animals have only a small bone articulated at the lower end of the tibia, in place of a fibula. We have thus a constant mutual relation between the organs or conformations, which appear to have no kind of connexion with each other; and the gradations of their forms invariably correspond, even in those cases in which we cannot give the rationale of their relations.

By thus employing the method of observation, where theory is no longer able to direct our views, we procure astonishing results. The smallest fragment of bone, even the most apparently insignificant apophysis, possesses a fixed and determinate

character, relative to the class, order, genus, and species of the animal to which it belonged; insomuch, that, when we find merely the extremity of a well-preserved bone, we are able, by careful examination, assisted by analogy and exact comparison, to determine the species to which it once belonged, as certainly as if we had the entire animal before us. Before venturing to put entire confidence in this method of investigation, in regard to fossil bones, I have very frequently tried it with portions of bones belonging to well-known animals, and always with such complete success, that I now entertain no doubt with regard to the results which it affords. I must acknowledge that I enjoy every kind of advantage for such investigations that could possibly be of use, by my fortunate situation in the Museum of Natural History; and, by assiduous researches for nearly fifteen years, I have collected skeletons of all the genera and sub-genera of quadrupeds, with those of many species in some of the genera, and even of several varieties of some species. With these aids, I have found it easy to multiply comparisons, and to verify, in every point of view, the application of the foregoing rules.

We cannot, in the present Essay, enter into a more lengthened detail of this method, and must refer for its entire explanation to the large work on Comparative Anatomy, which we propose to publish very soon, and in which all its laws will

be explained and illustrated. In the meantime, the intelligent reader may gather a great number of these from the work now laid before him, if he will take the trouble of attending to all the applications which we have made of them. He will there find that it is by this method alone that we have been guided, and that it has almost always been sufficient for the purpose of referring every fossil bone to its peculiar species, if belonging to one that still exists; to its genus, if belonging to an unknown species; to its order, if belonging to a new genus; and, finally, to its class, if belonging to an unknown order: And, in these three latter predicaments, to assign to it the proper characters for distinguishing it from the nearest resembling orders, genera, and species. Before the commencement of these researches, naturalists had done no more than this in regard even to such animal remains as were found in an entire state.

§ 28. *Results of the Researches respecting the Fossil Bones of Quadrupeds.**

In this manner we have ascertained and classified the fossil remains of seventy-eight different quadrupeds, in the viviparous and oviparous classes. Of these, forty-nine are distinct species hitherto entirely unknown to naturalists. Eleven or twelve others have such entire resemblance to

* Note M.

species already known, as to leave no doubts whatever of their identity; and the remaining sixteen or eighteen have considerable traits of resemblance to known species, but the comparison of these has not yet been made with so much precision as to remove all dubiety.

Of the forty-nine new or hitherto unknown species, twenty-seven are necessarily referable to seven new genera; while the other twenty-two new species belong to sixteen genera, or sub-genera, already known. The whole number of genera and sub-genera to which the fossil remains of quadrupeds hitherto investigated are referable, are thirty-six, including those belonging both to known and unknown species.

Of these seventy-eight species, fifteen which belong to eleven genera or sub-genera, are animals belonging to the class of oviparous quadrupeds; while the remaining sixty-three belong to the mammiferous class. Of these last, thirty-two species are hoofed animals, not ruminant, and reducible to ten genera; twelve are ruminant animals, belonging to two genera; seven are *gnawers*, referable to six genera; eight are carnivorous quadrupeds, belonging to five genera; two are toothless animals, of the sloth genus; and two are amphibious animals of two distinct genera.*

* As the author has already referred fifteen other species to what

§ 29. *Relations of the Species of Fossil Bones, with the Strata in which they are found.*

Notwithstanding the considerable number of these fossil bones already discovered and ascertained, it would be premature to attempt establishing any conclusions deduced from them in regard to the theory of the earth, as they are not in sufficient proportion to the entire number of genera and species which, in all probability, are buried in the strata of the earth. Hitherto the bones of the larger species have chiefly been collected, as more obvious to the labourers, while those of smaller animals are usually neglected, unless when they fall by accident in the way of a naturalist, or when some other remarkable circumstance, such as their extreme abundance in any particular place, attracts even the attention of common people.

The most important consideration, that which has been the chief object of my researches, and which constitutes their legitimate connexion with the theory of the earth, is to ascertain the particular strata in which each of the species was found, and to inquire if any of the general laws could be ascertained, relative either to the zoological subdivisions, or to the greater or less resemblance be-

he terms the oviparous class of quadrupeds, the two *amphibious* animals here mentioned probably belong to the order of cetaceous mammiferous animals, and not to the *amphibiæ* of the Linnæan system.—*Transl.*

tween these fossil species and those which still exist upon the earth.

The laws already recognised with respect to these relations are very distinct and satisfactory.

It is, in the first place, clearly ascertained, that the oviparous quadrupeds are found considerably earlier, or in more ancient strata, than those of the viviparous class. Thus the crocodiles of Honfleur and of England are found underneath the chalk. The *monitors* of Thuringia would be still more ancient, if, according to the Wernerian school, the copper-slate in which they are contained, along with a great number of fishes supposed to have belonged to fresh water, is to be placed among the most ancient strata of the secondary or flætz formations. The great alligators, or crocodiles, and the tortoises of Maestricht, are found in the chalk formation; but these are both marine animals.

This earliest appearance of fossil bones seems to indicate, that dry lands and fresh waters must have existed before the foundation of the chalk strata. Yet neither at that early epoch, nor during the formation of the chalk strata, nor even for a long period afterwards, do we find any fossil remains of mammiferous land-quadrupeds.

We begin to find the bones of mammiferous sea-animals, namely, of the lamantin and of seals, in the coarse shell limestone which immediately co-

vers the chalk strata in the neighbourhood of Paris. But no bones of mammiferous land-quadrupeds are to be found in that formation; and notwithstanding the most careful investigations, I have never been able to discover the slightest traces of this class, except in the formations which lie over the coarse limestone strata; but immediately on reaching these more recent formations, the bones of land-quadrupeds are discovered in great abundance.

As it is reasonable to believe that shells and fish did not exist at the period of the formation of the primitive rocks, we are also led to conclude that the oviparous quadrupeds began to exist along with the fishes, and at the commencement of the period which produced the secondary formations; while the land-quadrupeds did not appear upon the earth till long afterwards, and until the coarse shell limestone had been already deposited, which contains the greater part of our genera of shells, although of quite different species from those that are now found in a natural state.

It is remarkable that those coarse limestone strata, which are chiefly employed at Paris for building, are the last formed strata which indicate a long and quiet continuance of the water of the sea above the surface of our continent. Above them, indeed, there are found formations containing abundance of shells and other productions of

the sea; but these consist of alluvial materials, sand, marle, sandstone, or clay, which rather indicate transportations that have taken place with some degree of violence, than strata formed by quiet depositions; and where some regular rocky strata, of inconsiderable extent and thickness, appear above or below these alluvial formations, they generally bear the marks of having been deposited from fresh water.

All the known specimens of the bones of viviparous land quadrupeds, have either been found in these formations from fresh water, or in the alluvial formations; whence there is every reason to conclude that these animals have only begun to exist, or at least to leave their remains in the strata of our earth, since the last retreat of the sea but one, and during that state of the world which preceded its last irruption.

There is also a determinate order observable in the disposition of these bones in regard to each other, which indicates a very remarkable succession in the appearance of the different species. All the genera which are now unknown as the *palæotheria*, *anaplotheria*, &c. with the localities of which we are thoroughly acquainted, are found in the most ancient of those formations of which we are now treating, or those which are placed directly over the coarse limestone strata. It is chiefly they which occupy the regular strata that have

been deposited from fresh water, or certain alluvial beds of very ancient formation, generally composed of sand and rounded pebbles; which were perhaps the earliest alluvial formations of the ancient world. Along with these there are also found some lost species of known genera, but in small numbers; together with some oviparous quadrupeds and some fish, which appear to have been inhabitants of fresh water. The strata containing these are always more or less covered with alluvial formations, filled with shells and other productions of the sea.

The most celebrated of the unknown species belonging to known genera, or to genera nearly allied to those that are known, as the fossil elephant, rhinoceros, hippopotamus, and *mastodon*, are never found along with the more ancient genera; but are only contained in alluvial formations, sometimes along with sea-shells, and sometimes with fresh-water shells, but never in regular rocky strata. Every thing found along with these species is either, like them, unknown, or at least doubtful.

Lastly, the bones of species which are apparently the same with those that still exist alive, are never found except in the very latest alluvial depositions, or those which are either formed on the sides of rivers, or on the bottoms of ancient lakes or marshes now dried up, or in the substance of beds of peat, or in the fissures and ca-

verns of certain rocks, or at small depths below the present surface, in places where they may have been overwhelmed by debris, or even buried by man: And, although these bones are the most recent of all, they are almost always, owing to their superficial situation, the worst preserved.

It must not, however, be thought that this classification of the various mineral repositories is as certain as that of the species, and that it has nearly the same character of demonstration. Many reasons might be assigned to show that this could not be the case. All the determinations of species have been made, either by means of the bones themselves, or from good figures; whereas it has been impossible for me personally to examine the places in which these bones were found. Indeed I have often been reduced to the necessity of satisfying myself with vague and ambiguous accounts, given by persons who did not know well what was necessary to be noticed; and I have still more frequently been unable to procure any information whatever on the subject.

Secondly, these mineral repositories are subject to infinitely greater doubts in regard to their successive formations, than are the fossil bones respecting their arrangement and determination. The same formation may seem recent in those places where it happens to be superficial, and ancient where it has been covered over by suc-

ceeding formations. Ancient formations may have been transported into new situations by means of partial inundations, and may thus have covered over recent formations containing bones; they may have been carried over by debris so as to surround these recent bones, and may have mixed with them the productions of the ancient sea, which they previously contained. Anciently deposited bones may have been washed out from their original situations by the waters, and been afterwards enveloped in recent alluvial formations. And, lastly, recent bones may have fallen into the crevices and caverns of ancient rocks, where they may have been covered up by stalactites or other incrustations. In every individual instance, therefore, it becomes necessary to examine and appreciate all these circumstances, which might otherwise conceal the real origin of extraneous fossils; and it rarely happens that the people who found these fossil bones were aware of this necessity, and consequently the true characters of their repositories have almost always been overlooked or misunderstood.

Thirdly, there are still some doubtful species of these fossil bones, which must occasion more or less uncertainty in the result of our researches, until they have been clearly ascertained. Thus the fossil bones of horses and buffaloes, which have been found along with those of elephants, have not hitherto presented sufficiently distinct specific cha-

racters; and such geologists as are disinclined to adopt the successive epochs which I have endeavoured to establish in regard to fossil bones, may for many years draw from thence an argument against my system, so much the more convenient as it is contained in my own work. Even allowing that these epochs are liable to some objections, from such as have slightly considered some particular fact, I am not the less satisfied that those who shall take a comprehensive view of the phenomena, will not be checked by inconsiderable and partial difficulties, but will be led to conclude, as I have done, that there has at least been one succession, and very probably two, in the class of quadrupeds, before the appearance of those races which now inhabit the surface of our globe.

§ 30. *Proofs that the extinct Species of Quadrupeds are not Varieties of the presently existing Species.*

The following objection has already been started against my conclusions. Why may not the presently existing races of mammiferous land-quadrupeds be mere modifications or varieties of those ancient races which we now find in the fossil state, which modifications may have been produced by change of climate and other local circumstances, and since raised to the present excessive difference, by the operation of similar causes during a long succession of ages?

This objection may appear strong to those who believe in the indefinite possibility of change of forms in organized bodies, and think that during a succession of ages, and by alterations of habitudes, all the species may change into each other, or one of them give birth to all the rest. Yet to these persons the following answer may be given from their own system: If the species have changed by degrees, as they assume, we ought to find traces of this gradual modification. Thus, between the *palæotherium* and the species of our own days, we should be able to discover some intermediate forms; and yet no such discovery has ever been made. Since the bowels of the earth have not preserved monuments of this strange genealogy, we have a right to conclude, That the ancient and now extinct species were as permanent in their forms and characters as those which exist at present; or at least, That the catastrophe which destroyed them did not leave sufficient time for the production of the changes that are alleged to have taken place.

In order to reply to those naturalists who acknowledge that the varieties of animals are restrained by nature within certain limits, it would be necessary to examine how far these limits extend. This is a very curious inquiry, and in itself exceedingly interesting under a variety of relations, but has been hitherto very little attended to. It requires that we should define accu-

rately what is, or ought to be, understood by the word species, which may be thus expressed :—*A species comprehends all the individuals which descend from each other, or from a common parentage, and those which resemble them as much as they do each other.* Thus the different races which they have generated from them are considered as varieties but of one species. Our observations, therefore, respecting the differences between the ancestors and the descendants, are the only rules by which we can judge on this subject; all other considerations being merely hypothetical, and destitute of proof. Taking the word *variety* in this limited sense, we observe that the differences which constitute this variety depend upon determinate circumstances, and that their extent increases in proportion to the intensity of the circumstances which occasion them.

Upon these principles it may be observed, that the most superficial characters are the most variable. Thus colour depends much upon light; thickness of hair upon heat; size upon abundance of food, &c. In wild animals, however, even these varieties are greatly limited by the natural habits of the animal, which does not willingly migrate from the places where it finds insufficient quantity what is necessary for the support of its species, and does not even extend its haunts to any great distances, unless it also finds all these circumstances conjoined. Thus, although the wolf and the

fox inhabit all the climates from the torrid to the frigid zone, we hardly find any other differences among them, through the whole of that vast space, than a little more or a little less beauty in their furs. I have compared the skulls of foxes from the most northern regions and from Egypt with those of France, and found no differences but what might naturally be expected in different individuals. The more savage animals, especially those which are carnivorous, being confined within narrower limits, vary still less; and the only difference between the hyena of Persia and that of Morocco, consists in a thicker or a thinner mane.

Wild animals which subsist upon herbage feel the influence of climate a little more extensively, because there is added to it the influence of food, both in regard to its abundance and its quality. Thus the elephants of one forest are larger than those of another; their tusks also grow somewhat longer in places where their food may happen to be more favourable for the production of the substance of ivory. The same may take place in regard to the horns of stags and rein-deer. But let us examine two elephants the most dissimilar that can be conceived, we shall not discover the smallest difference in the number and articulations of the bones, the structure of the teeth, &c.

Besides, the species of herbivorous animals, in their wild state, seem more restrained from migra-

16

ting and dispersing than the carnivorous species, being influenced both by climate and by the kind of nourishment which they need.

Nature appears also to have guarded against the alterations of species which might proceed from mixture of breeds, by influencing the various species of animals with mutual aversion from each other. Hence all the cunning and all the force that man is able to exert is necessary to accomplish such unions, even between species that have the nearest resemblances. And when the mule-breeds that are thus produced by these forced conjunctions happen to be fruitful, which is seldom the case, this fecundity never continues beyond a few generations, and would not probably proceed so far, without a continuance of the same cares which excited it at first. Thus we never see in a wild state intermediate productions between the hare and the rabbit, between the stag and the doe, or between the martin and the weasel. But the power of man changes this established order, and contrives to produce all these intermixtures of which the various species are susceptible, but which they would never produce if left to themselves.

The degrees of these variations are proportional to the intensity of the causes that produce them, namely, the slavery or subjection under which those animals are to man. They do not proceed

far in half-domesticated species. In the cat, for example, a softer or harsher fur, more brilliant or more varied colours, greater or less size—these form the whole extent of the varieties in the species; the skeleton of the cat of Angora differs in no regular and constant circumstances from the wild cat of Europe.

In the domesticated herbivorous quadrupeds, which man transports into all kinds of climates, and subjects to various kinds of management, both in regard to labour and nourishment, he procures certainly more considerable variations, but still they are all merely superficial. Greater or less size; longer or shorter horns, or even the want of these entirely; a hump of fat, larger or smaller on the shoulder; these form the chief differences among particular races of the *bos taurus*, or domestic black cattle; and these differences continue long in such breeds as have been transported to great distances from the countries in which they were originally produced, when proper care is taken to prevent crossing.

The innumerable varieties in the breeds of the *ovis aries*, or common sheep, are of a similar nature, and chiefly consist in differences of their fleeces, as the wool which they produce, is a very important object of attention. These varieties, though not quite so perceptible, are yet sufficiently marked among horses. In general the forms

of the bones are very little changed; their connexions and articulations, and the form and structure of the large grinding teeth, are invariably the same. The small size of the tusks in the domesticated hog, compared with the wild boar of which it is only a cultivated variety, and the junction of its cloven hoofs into one solid hoof, observable in some races, form the extreme point of the differences which man has been able to produce among herbivorous domesticated quadrupeds.

The most remarkable effects of the influence of man are produced upon that animal which he has reduced most completely under subjection. Dogs have been transported by mankind into every part of the world, and have submitted their actions to his entire direction. Regulated in their sexual unions by the pleasure or caprice of their masters, the almost endless varieties of dogs differ from each other in colour; in length and abundance of hair, which is sometimes entirely wanting; in their natural instincts; in size, which varies in measure as one to five, amounting, in some instances, to more than an hundred fold in bulk; in the forms of their ears, noses, and tails; in the relative length of their legs; in the progressive developement of the brain in several of the domesticated varieties, occasioning alterations, even in the form of the head; some of them having long slender muzzles with a flat forehead; others having short muzzles, with the forehead convex, &c. insomuch that the apparent differences between a mas-

tiff and a water-spaniel, and between a greyhound and a pug-dog, are even more striking than between almost any of the wild species of a genus. Finally, and this may be considered as the maximum of known variation in the animal kingdom, some races of dogs have an additional claw on each hind-foot, with corresponding bones of the tarsus; as there sometimes occur in the human species some families that have six fingers on each hand. Yet, in all these varieties, the relations of the bones with each other remains essentially the same, and the form of the teeth never changes in any perceptible degree, except that in some individuals one additional false grinder occasionally appears, sometimes on the one side, and sometimes on the other.*

It follows from these observations, that animals have certain fixed and natural characters, which resist the effects of every kind of influence, whether proceeding from natural causes or human interference; and we have not the smallest reason to suspect that time has any more effect upon them than climate.

I am well aware that some naturalists lay prodigious stress on the thousands of years which they can call into action by a dash of their pens.

* See, in the Annals of the Museum, XVIII. 333., a memoir by my brother on the varieties of dogs, which he drew up at my request, from a series of skeletons of all the varieties of dogs, prepared by me expressly on purpose.

In such matters, however, our only way of judging as to the effects which may be produced by a long period of time, is by multiplying, as it were, such as are produced by a shorter known time. With this view I have endeavoured to collect all the ancient documents respecting the forms of animals; and there are none equal to those furnished by the Egyptians, both in regard to their antiquity and abundance. They have not only left us representations of animals, but even their identical bodies embalmed and preserved in the catacombs.

I have examined with the greatest attention the engraved figures of quadrupeds and birds upon the numerous obelisks brought from Egypt to ancient Rome; and all these figures, one with another, have a perfect resemblance to their intended objects, such as they still are in our days.

My learned colleague, M. Geoffroy Saint Hilaire, convinced of the importance of this research, carefully collected in the tombs and temples of Upper and Lower Egypt as many mummies of animals as he could procure. He has brought home the mummies of cats, ibises, birds of prey, dogs, monkies, crocodiles, and the head of a bull; and after the most attentive and detailed examination, not the smallest difference is to be perceived between these animals and those of the same species which we now see, any more than between the human mummies and the skeletons of men of the pre-

sent day. Some slight differences are discoverable between ibis and ibis, for example, just as we now find differences in the descriptions of naturalists; but I have removed all doubts on that subject, in a memoir on the Ibis of the ancient Egyptians, in which I have clearly shown that this bird is precisely the same in all respects at present that it was in the days of the Pharaohs.* I am aware that in these I only cite the monuments of two or three thousand years back; but this is the most remote antiquity to which we can resort in such a case.

From all these well-established facts, there does not seem to be the smallest foundation for supposing, that the new genera which I have discovered or established among extraneous fossils, such as the *palæotherium*, *anoplotherium*, *megalonyx*, *mastodon*, *pterodactylis*, &c. have ever been the sources of any of our present animals, which only differ so far as they are influenced by time or climate. Even if it should prove true, which I am far from believing to be the case, that the fossil elephants, rhinoceroses, elks, and bears, do not differ farther from the presently existing species of the same genera, than the present races of dogs differ among themselves, this would by no means

* In that dissertation, the ibis of the ancient Egyptians is shown to be a species of *numenius*, or curlew, denominated by Cuvier *numenius ibis;* the same bird described in Bruce's Travels under the name of *abu-hannes.—Transl.*

be a sufficient reason to conclude that they were of the same species; since the races or varieties of dogs have been influenced by the trammels of domesticity, which these other animals never did, and indeed never could experience.

Farther, when I endeavour to prove that the rocky strata contain the bony remains of several genera, and the loose strata those of several species, all of which are not now existing animals on the face of our globe, I do not pretend that a new creation was required for calling our present races of animals into existence. I only urge that they did not anciently occupy the same places, and that they must have come from some other part of the globe. Let us suppose, for instance, that a prodigious inroad of the sea were now to cover the continent of New-Holland with a coat of sand and other earthy materials; this would necessarily bury the carcasses of many animals belonging to the genera of *kanguroo*, *phascoloma*, *dasyurus*, *peramela*, *flying-phalangers*, *echidna*, and *ornithorynchus*, and would consequently entirely extinguish all the species of all these genera, as not one of them is to be found in any other country. Were the same revolution to lay dry the numerous narrow straits which separate New-Holland from New-Guinea, the Indian islands, and the continent of Asia, a road would be opened for the elephants, rhinoceroses, buffaloes, horses, camels, tigers, and all the other Asiatic animals, to occupy a land in which they are hitherto

unknown. Were some future naturalist, after becoming well acquainted with the living animals of that country in this supposed new condition, to search below the surface on which these animals were nourished, he would then discover the remains of quite different races.

What New Holland would then be, under these hypothetical circumstances, Europe, Siberia, and a large portion of America, actually now are. Perhaps hereafter, when other countries shall be investigated, and New Holland among the rest, they also may be found to have all undergone similar revolutions, and perhaps may have made reciprocal changes of animal productions. If we push the former supposition somewhat farther, and, after the supply of Asiatic animals to New Holland, admit that a subsequent catastrophe might overwhelm Asia, the primitive country of the migrated animals, future geologists and naturalists would perhaps be equally at a loss to discover whence the then living animals of New Holland had come, as we now are to find out the original habitations of our present fossil animals.

§ 32. *Proofs that there are no Human Bones in a Fossil State.*

I now proceed to apply the previous reasonings to the human race. It is quite undeniable that no human remains have been hitherto discovered

among the extraneous fossils; and this furnishes a strong proof that the extinct races which are now found in a fossil state, were not varieties of known species, since they never could have been subjected to human influence.

When I assert that human bones have not been hitherto found among extraneous fossils, I must be understood to speak of fossils, or petrifications, properly so called: As in peat depositions or turf bogs, and in alluvial formations, as well as in ancient burying-grounds, the bones of men with those of horses, and other ordinary existing species of animals, may readily enough be found; but among the fossil *palæotheria*, the elephants, the rhinoceroses, &c. the smallest fragment of human bone has never been detected. Most of the labourers in the gypsum quarries about Paris are firmly persuaded that the bones they contain are in a great part human: but after having seen and carefully examined many thousands of these bones, I may safely affirm that not a single fragment of them has ever belonged to our species.

I carefully examined at Pavia the collection of extraneous fossil bones brought there by Spalanzani from the island of Cerigo; and, notwithstanding the assertion of that celebrated observer, I affirm that there is not a single fragment among them that ever formed part of a human skeleton.

In my fourth volume, the *homo diluvii testis* of Scheuchzer is restored to the *proteus*, its true genus; and in a still more recent examination of it at Haerlem, allowed by the politeness of M. Van Marum, who even permitted me to uncover some parts that were before enveloped in the stone, I obtained decisive proof of what I had before announced.

Among the fossil bones discovered at Cronstadt, the fragment of a jaw, together with some articles of human manufacture, was found; but it is well known that the ground was dug up without any precautions, and no notes were taken of the different depths at which each article was found. Everywhere else, the fragments of bone considered as human have been found to belong to some animal, either when the fragments themselves have been actually examined, or even when their engraved figures have been inspected. Such real human bones as have been found in a fossil state, belonged to bodies which had fallen into crevices of rocks, or had been left in the forsaken galleries of ancient mines, and were covered up by incrustation. The same has been the case with all articles of human fabric. The pieces of iron which have been found at Montmartre, are fragments of the iron tools used in the quarries for putting in blasts of gunpowder, and which sometimes break in the stone.

Yet human bones preserve equally well with those of animals, when placed in the same circumstances; and there is no observable difference in this respect in Egypt between the mummies of men and those of quadrupeds. I have picked up, from the excavations made lately in the ancient church at St. Genevieve, human bones that had been interred below the remains of the first race, which may even have belonged to some princes of the family of Clovis, and which still retained their forms very perfectly.* We do not find in ancient fields of battle, that the skeletons of men are more wasted than those of horses, except in so far as they may be influenced by size, and we find among extraneous fossils the bones of animals as small as rats, perfectly well preserved.

Every circumstance, therefore, contributes to establish this position—That the human race did not exist in the countries in which the fossil bones of animals have been discovered, at the epoch when these bones were covered up; as there cannot be a single reason assigned why men should have entirely escaped from such general catastrophes; or, if they also had been destroyed and covered over at the same time, why their remains should not now be found along with those of the other animals. I do not presume, however, to conclude that man did not exist at all before these

---

* M. Fourcroy has given an analysis of these bones.

epochs. He may have then inhabited some narrow regions, whence he went forth to repeople the earth after the cessation of these terrible revolutions and overwhelmings. Perhaps even the places which he then inhabited may have been sunk into the abyss, and the bones of that destroyed human race may yet remain buried under the bottom of some actual seas; all except a small number of individuals who were destined to continue the species.

However this may have been, the establishment of mankind in those countries in which the fossil bones of land-animals have been found, that is to say, in the greatest part of Europe, Asia, and America, must necessarily have been posterior not only to the revolutions which covered up these bones, but also to those other revolutions, by which the strata containing the bones have been laid bare. Hence it clearly appears, that no argument for the antiquity of the human race in those countries can be founded either upon these fossil bones or upon the more or less considerable collections of rocks or earthy materials by which they are covered.

§ 31. *Proofs of the recent Population of the World, and that its present Surface is not of very ancient Formation.*

On the contrary, by a careful investigation of what has taken place on the surface of the globe

since it has been laid dry for the last time, and its continents have assumed their present form, at least in such parts as are somewhat elevated above the level of the ocean, it may be clearly seen that this last revolution, and consequently the establishment of our existing societies, could not have been very ancient. This result is one of the best established and least attended to, in rational zoology; and it is so much the more valuable, as it connects natural and civil history together in one uninterrupted series.

When we endeavour to estimate the quantity of effects produced in a given time by any causes still acting, by comparing them with the effects which these causes have produced since they began to operate, we may determine nearly the period at which their action commenced; which must necessarily be the same period with that in which our continents assumed their presently existing forms, or with that of the last retreat of the waters. It must have been since that last retreat of the waters, that the acclivities of our mountains have begun to disintegrate, and to form slopes or taluses of the debris at their bottoms and upon their sides; that our rivers have begun to flow in their present courses, and to form alluvial depositions; that our existing vegetation has begun to extend itself, and to form vegetable soil; that our present cliffs, or steep sloping coasts, have begun to be worn away by the waters of the sea;

that our actual downs, or sand-hills, have begun to be blown up by the winds. And, dating from the same epoch, colonies of the human race must have then begun, for the first or for the second time, to spread themselves, and to form new establishments in places fitted by nature for their reception.

I do not here take the action of volcanoes into the account, not only because of the irregularity of their eruptions, but because we have no proofs of their not having been able to act below the sea; and because, on that account, they cannot serve us as a measure of the time which has elapsed since its last retreat.

MM. Deluc and Dolomieu have most carefully examined the progress of the formation of new grounds by the collection of slime and sand washed down by the rivers; and, although exceedingly opposed to each other on many points of the theory of the earth, they agree exactly on this. These formations augment very rapidly; they must have increased with the greatest rapidity at first, when the mountains furnished the greatest quantity of materials to the rivers,* and yet their extent still continues to be extremely limited.

* One instance will be found appended to this Essay, of modern alluvial formations proceeding with considerably increased rapidity,

The memoir by M. Dolomieu respecting Egypt,* tends to prove that the tongue of land on which Alexander caused his famous commercial city to be built, did not exist in the days of Homer; because they were then able to navigate directly from the island of Pharos into the gulf afterwards called *Lacus Mareotis;* and that this gulf, as indicated by Menelaus, was between fifteen and twenty leagues in length. Supposing this to be accurate, it had only required the lapse of nine hundred years, from the days of Homer to the time of Strabo, to reduce matters to the situation described by this latter author, when that gulf was reduced to the state of a lake only six leagues long.

It is a more certain fact, that since that time a still greater change has taken place. The sands, which have been thrown up by the sea and the winds, have formed, between the isle of Pharos and the site of ancient Alexandria, an isthmus more than four hundred yards broad, on which the modern city is now built. These collections of sand have also blocked up the nearest mouth of the Nile, and have reduced the lake Mareotis almost to nothing; while, in the course of the same period, the Nile

in the researches of M. Prony, respecting the alluvial depositions at the mouths of the Po.—*Transl.*

* In the Journal de Physique, vol. XLII.

has deposited alluvial formations all along the rest of the coast. In the time of Herodotus, the coast of the Delta extended in a straight line, and is even represented in that direction in the maps constructed for the geography of Ptolemy: but since then the coast has so far advanced as to have assumed a semicircular projection into the Mediterranean. The cities of Rosetta and Damietta, built on the sea-coast less than a thousand years ago, are now two leagues distant from the sea.

We may learn in Holland and Italy, how rapidly the Rhine, the Po, and the Arno, since they have been confined within dikes, now elevate their beds, and push forward the alluvial grounds at their mouths towards the sea, forming long projecting promontories at their sides; and it may be concluded, from this assured fact, that these rivers have not required the lapse of many centuries to deposit the low alluvial plains through which they now flow.

Many cities, which were flourishing sea-ports in well-known periods of history, are now several leagues inland, and several have even been ruined by this change. The inhabitants of Venice at present find it exceedingly difficult to preserve the *lagunes*, by which that once celebrated city is separated from the continent of Italy, from filling up; and there can be no doubt that she will

some day become united to the main land, in spite of every effort to preserve her insular situation.*

We learn from Strabo, that Ravenna stood among *lagunes*, in the time of Augustus, as Venice does now; but Ravenna is now at the distance of a league from the sea. Spina had been originally built by the Greeks on the sea-coast; but in the time of Strabo the sea was removed to the distance of ninety stadia. This city has been long since destroyed. Adria, which gave name to the Adriatic, was, somewhat more than twenty centuries ago, the chief port of that sea, from which it is now at the distance of six leagues. The Abbe Fortis has even produced strong evidence for believing that the Euganian hills may have been islands, at a period somewhat more remote.

M. de Prony, a learned member of the Institute, and inspector-general of bridges and highways, has communicated to me some very valuable observations, to explain the changes which have taken place on the flat shores usually denominated the *Littoral* of the Adriatic, and which will be found appended to this Essay. Having been directed by government to examine and report upon the precautions which might be em-

* See a Memoir on the Lagunes of Venice, by M. Forfait.

ployed for preventing the devastations occasioned by the floods of the Po, he ascertained that this river has so greatly raised the level of its bottom, since it was shut in by dikes, that its present surface is higher than the roofs of the houses in Ferrara. At the same time, the alluvial additions produced by this river have advanced so rapidly into the sea, that, by comparing old charts with the present state, the coast appears to have gained no less than fourteen thousand yards since the year 1604, giving an average of an hundred and eighty to two hundred feet* yearly; and in some places the average amounts to two hundred feet. The Adige and the Po are both at present higher than the intervening lands; and the only remedy for preventing the disasters which are now threatened by their annual overflowings, would be to open up new channels for the more ready discharge of their waters, through the low grounds which have been formed by their alluvial depositions.

Similar causes have produced similar effects along the branches of the Rhine and the Maese; owing to which all the richest districts of Holland have the frightful view of their great rivers held up

---

* In the appended extract from the Memoir of M. Prony, the older average yearly increase is stated at 25 *metres*, or 82 English feet and a quarter of an inch; and the average of the last 200 years at 70 *metres*, or 229 feet 7 inches and 9-tenths yearly.—*Transl.*

by dikes, at the height of twenty or even thirty feet above the level of the land.

M. Wiebeking, director of bridges and highways in the kingdom of Bavaria, has given an excellent memoir upon this subject, so highly important to be known and understood thoroughly, both by the people and the government, in all countries liable to these changes. In this memoir he has demonstrated that all rivers are continually elevating the levels of their beds, more or less, according to circumstances.

This formation and increase of new grounds by alluvial depositions, proceeds with as much rapidity along the coasts of the North Sea as on those of the Adriatic. These additions can be easily traced in Friesland and Groningen, where the epoch of the first dikes, constructed by the Spanish governor, Gaspard Robles, is well known to have been in 1570. An hundred years afterwards, the alluvial depositions had added in some places three quarters of a league of new land on the outside of these dikes: And the city of Groningen, partly built upon the ancient soil which has no connexion with the present sea, being a calcarious formation, in which the same species of shells are found as in the coarse limestone formations near Paris, is only six leagues from the sea. Having been upon the spot, I can give my testimony to the facts already so well stated by M. Deluc in his Letters to the

Queen of England. The same phenomenon is as distinctly observable all along the coasts of East Friesland, and the countries of Bremen and Holstein, as the period at which the new grounds were enclosed by dikes for the first time is perfectly well known, and the extent that has been gained since can be easily measured. These new alluvial lands, left by the sea and the rivers, are of astonishing fertility, and are so much the more valuable as the ancient soil of these countries, being mostly covered by barren heaths and peat-mosses, is almost incapable of cultivation; so that the alluvial lands alone produce subsistence for the many populous cities that have been built along these coasts since the middle age, and which probably might not have reached their present flourishing condition, without the aid of these rich grounds, which have been, as it were, created by the rivers, and to which they are continually making additions.

If the size which Herodotus attributed to the sea of Asoph, which he says was equal to the Euxine,* had been less vaguely indicated, and if we could certainly ascertain what he understood to be the *Gerrhus*,† we should there find strong additional proofs of the great changes produced by the rivers, and of the rapidity with which these

* Melpomene, LXXXVI. † Ibid. LVI.

have been made. The alluvial depositions of these rivers, in the course of 2250 years since the time of Herodotus, have reduced the sea of Asoph to its present comparatively small size; have shut up entirely that branch of the Dneiper which formerly joined the *Hypacyris*, and discharged its waters along with that river into the gulf called *Carcinites*, now the *Olu-Degnitz ;* and have now almost reduced the *Hypacyris* and the *Gerrhus* to nothing.*

We should possess proofs no less strong of the same thing, could we be certain that the Oxus or Sihon, which flows at present into Lake Aral, formerly reached the Caspian sea: But the proofs which we possess on all these points are too vague, and even contradictory, to be admitted in support of physical propositions, and besides, we are in possession of facts sufficiently conclusive, without being under the necessity of having recourse to those which are doubtful.

The downs or sand-hills which are thrown up by the sea upon low flat coasts, when the bed of the sea happens to be composed of sand, have been

---

* See the Geography of Herodotus by M. Rennel, and the Physical Geography of the Black Sea, &c. by M. Dureau de la Malle.

In the latter work, p. 170, M. Dureau supposes Herodotus to have said that the Boristhenes and the Hypanis flowed into the Palus Meotis: But Herodotus, in Melpomene, LIII. only says that these two rivers discharged their waters into the same marsh; that is, into the Liman, exactly as in the present day ; and Herodotus does not carry the Gerrhus and the Hypacyris any farther.

already mentioned. Wherever human industry has not succeeded to fix these downs, they advance as surely and irresistibly upon the land, as the alluvial formations from the rivers encroach upon the sea. In their progress inland, they push before them great pools of water, formed by the rain which falls on the neighbouring grounds, and which has no means of running off in consequence of the obstructions interposed by the downs. In several places these proceed with a frightful rapidity, overwhelming forests, houses, and cultivated fields, in their irresistible progress. Those upon the coast of the Bay of Biscay* have overwhelmed a great number of villages, which are mentioned in the records of the middle age; and even at present, in the single department of *Landes*, they threaten no fewer than ten with almost inevitable destruction. One of these, named Mimigan, has been in danger for the last fifteen years from a sand-hill of more than sixty feet in perpendicular height, which obviously continues to advance.

In the year 1802, the pools overwhelmed five fine farm-houses belonging to the village of St. Julian.† They have long covered up an ancient Roman road, leading from Bourdeaux to Bayonne, and which could still be seen about thirty years ago, when the waters were lower than they are now.‡

* See Report respecting the Downs of the Gulf of Gascony, or Bay of Biscay, by M. Tassin, *Mont-de-Marsan, an.* X.

† Memoir on the Means of fixing the Downs, by M. Bremontier.

‡ Report of M. Tassin, formerly cited.

The river Adour, which is formerly known to have passed Old Boucat to join the sea at Cape Breton, is now turned to the distance of more than two thousand four hundred yards.

The late M. Bremontier, inspector of bridges and highways, who made several extensive works to endeavour to stop the progress of these downs, estimated their progress at sixty feet yearly, and in some places at seventy-two feet. According to this calculation, it would require two thousand years to enable them to arrive at Bourdeaux; and, on the same data, they have taken somewhat more than four thousand years to reach their present situations.*

The *turbaries*, or peat-mosses, which have been formed so generally in the northern parts of Europe, by the accumulation of the remains of *sphagnum* and other aquatic mosses, afford another means of estimating the time which has elapsed since the last retreat of the sea from our present continents. These mosses increase in height in proportions which are determinate in regard to each. They surround and cover up the small knolls upon which they are formed; and several of these knolls have been covered over within the memory of man. In other places the mosses gradually descend along the valleys, extending downwards like the *glaciers;* but these latter melt every

* Memoir of M. Bremontier.

year at their lower edges, while the mosses are not stopped by any thing whatever in their regular increase. By sounding their depth down to the solid ground, we may form some estimate of their antiquity; and it may be asserted respecting these mosses, as well as respecting the downs, that they do not derive their origin from an indefinitely ancient epoch.

The same observations may be made in regard to the slips, or fallings, which sometimes take place at the bottom of all steep slopes in mountainous regions, and which are still very far from having covered these over. But as no precise measures of their progress have hitherto been applied, we shall not insist upon them at any greater length.

§ 32. *Proofs, from Traditions, of a great Catastrophe, and subsequent Renewal of Human Society.*

From all that has been said, it may be seen that nature everywhere distinctly informs us that the commencement of the present order of things cannot be dated at a very remote period; and it is very remarkable, that mankind everywhere speak the same language with nature, whether we consult their natural traditions on this subject, or consider their moral and political state, and the intellectual attainments which they had made at the time when they began to have authentic historical monu-

ments. For this purpose we may consult the histories of nations in their most ancient books, endeavouring to discover the real facts which they contain, when disengaged from the interested fictions which often render the truth obscure.

The Pentateuch has existed in its present form at least ever since the separation of the ten tribes under Jeroboam, since it was received as authentic by the Samaritans as well as by the Jews; and this assures us of the actual antiquity of that book being not less than two thousand eight hundred years.* Besides this, we have no reason to doubt of the book of Genesis having been composed by Moses, which adds five hundred years to its antiquity.

Moses and his people came out of Egypt, which is universally allowed by all the nations of the west to have been the most anciently civilized kingdom on the borders of the Mediterranean. The legislator of the Jews could have no motive for shortening the duration of the nations, and would even have disgraced himself in the estimation of his own, if he had promulgated a history of the human race contradictory to that which they must have learnt by tradition in Egypt. We may therefore conclude, that the Egyptians had at this time no

* Introduction to the Books of the Old Testament, by Eichhorn.—Leipsic, 1803.

other notions respecting the antiquity of the human race than are contained in the book of Genesis. And, as Moses establishes the event of an universal catastrophe, occasioned by an irruption of the waters, and followed by an almost entire renewal of the human race, and as he has only referred it to an epoch fifteen or sixteen hundred years previous to his own time, even according to those copies which allow the longest interval, it must necessarily have occurred rather less than five thousand years before the present day.*

The same notions seem to have prevailed in Chaldea on this subject; as Berosus, who wrote at Babylon in the time of Alexander, speaks of the Deluge nearly in the same terms with Moses, and supposes it to have happened immediately before Belus, the father of Ninus.†

Whatever may be the authenticity of the writings attributed to Sanconiatho, he does not appear to have mentioned the Deluge in his History of Phœnicia.‡ Yet this event seems to have

---

* Joseph. Antiq. Jud. lib. I. cap. 3.—Eusebii, Praep. Evang. lib. IX. cap. 4.—Syncelli, Chronogr.

† Eusebii, Præp. Ev. lib. I. cap. 10.

‡ The Deluge, according to the Hebrew text of the scriptures, took place 2348 years before the commencement of the Christian era, or 4160 years before the present year 1813. The creation of the world, on the same authority, was 5817 years ago; but the Samaritan text extends that event to the distance of 6513 years, and the Septuagint to 7685 years.—*Transl.*

been believed in Syria, as they showed in the temple of Hieropolis, at a period indeed long after, the abyss through which they pretended that its waters had run off.*

Even in Egypt this tradition appears to have been forgotten, as we do not find any traces of it in the most ancient remaining fragments from that country. All of these indeed are posterior to the devastations committed by Cambyses; and the little agreement there is among them sufficiently proves that they had been derived from mutilated fragments: For we cannot establish the smallest probable conformity between the lists of the kings of Egypt, as given by Herodotus in the era of Artaxerxes, by Erastosthenes and Manetho under the Ptolemies, and by Diodorus in the reign of Augustus: neither do they agree among themselves in the extracts which they pretend to have taken from the writings of Manetho.† Yet the Egyptian mythology seems to allude to these great events in the fabulous adventures of Typhon and Osiris. Besides, if the priests of Sais really gave the accounts to Solon, which are repeated by Critias in the writings of Plato, we must conclude that they had preserved some very exact traditions of a great revolution, though they had removed its epoch much farther back than was done by

* Lucian, de Dea Syria.

† See the English Ancient Universal History, vol. I.

Moses. They had even theoretically devised a series of alternate revolutions; one set occasioned by means of water, and the other by means of fire; which notion had also prevailed among the Assyrians, and even in Etruria.

The Greeks, who derived their civilization at a late period from Phœnicia and Egypt, mixed the confused ideas which they had received of the mythologies of these nations with the equally confused vestiges of their own earliest history. The sun, personified under the name of Ammon, or the Egyptian Jupiter, was converted into a prince of Crete. *Phta*, the grand artisan or creator of all things, was converted into Hephestes, or Vulcan, a smith of Lemnos. *Chom*, another symbol of the sun, or of the divine power, was transformed into Heracles, or Hercules, a prodigiously strong hero of Thebes. The cruel *Moloch* of the Phœnicians, the same with the *Remphah* of the Egyptians, became with them *Cronos*, or Time, who devoured his own children, and was afterwards metamorphosed into Saturn, King of Italy.* When any violent inundation took place during the reign of any of their princes, the Greeks afterwards de-

* See Jablonsky, Pantheon Ægyptiacum, and Gatterer, de Theogonia Egyptiorum, in the seventh volume of the Gottingen Memoirs.

These two authors do not agree any more than the ancients, as to the significations of the Egyptian divinities; but they perfectly agree with each other, and with the ancient writers, as to the gross alterations made respecting them by the Greeks.

scribed it with all the circumstances which had been handed down to them by tradition respecting the great deluge; and they represented Deucalion as having repeopled the earth, yet allowed a lengthened posterity to his uncle Atlas.

The incoherence of all these traditionary tales, while they attest the barbarism and ignorance of all the tribes around the Mediterranean, attest also the recentness of their establishments; and this very circumstance is in itself a strong proof of the existence of a great catastrophe. The Egyptians, it is true, spoke of hundreds of centuries, but these were filled by a succession of gods and demi-gods; and it is in a great degree ascertained in modern times, that the long series of years and of successive human kings which they placed after the demi-gods, and before the usurpation of the shepherds, belonged only to the successions of contemporaneous chiefs of several small states, instead of a single series of successive kings of all Egypt.

Macrobius* assures us that collections of observations of eclipses made in Egypt were preserved, which presupposed uninterrupted labour for at least twelve hundred years before the reign of Alexander. How comes it then, had this been the case, that Ptolemy should not have availed

* In Somnio Scipionis, 21.

himself of any of these observations, though made in the country where he wrote?

There was no great empire as yet established in Asia at the time of Moses. Even the Greeks, notwithstanding their ingenuity in inventing fables, did not pretend even to invent an antiquity for their own nation; for the most ancient colonies from Egypt and Phœnicia, by which they were reclaimed from a state of barbarism, are not carried back more than four thousand years from the present era; and the most ancient authors in which these colonies are mentioned, are a thousand years posterior to the events. The Phœnicians themselves had only been recently established in Syria, when they began to form establishments in Greece.

The astronomical observations of the Chaldeans, sent by Calisthenes to Aristotle, are said to have gone back for a period of four thousand years, if Simplicius is to be credited, who reports the story six hundred years after Aristotle. But the authenticity of this is exceedingly doubtful, as the Chaldean observations of eclipses actually preserved and cited by Ptolemy, do not go back more than two thousand five hundred years.* At

---

* It is not quite obvious, from the language of the author, whether these are meant as pointing backwards from the respective epoch of Aristotle and Ptolemy, or only from the present day: the latter must, however, be the case.—*Transl.*

all events, the Babylonian, or first Assyrian empire, could not have been long powerful, as there remained all around many unsubjected tribes, such as all those of Syria, until after the establishment of what is called the Second Kingdom of Assyria. The thousands of years therefore which the Chaldeans assumed, must have been equally fabulous with those of the Egyptians; or rather may be considered as astronomical periods, calculated backwards upon the basis of inaccurate observations: or merely as imaginary and arbitrary cycles, multiplied into themselves.*

The most reasonable among the ancients were of the same opinion, and have only carried back the reigns of Ninus and Semiramis, the earliest of the conquerors, a little more than four thousand years. After them history continues long silent;† whence it may even be strongly suspected that these were only late inventions of the historians.

Our existing civilization and learning have been uninterruptedly transmitted down to us from the Egyptians and Phœnicians, through the Greeks and Romans; and we have derived immediately from the Jews our more pure ideas of morals and religion. Some small portions of knowledge have

* See Memoire of D. de Guignes in the Acad. des Belles Lettres, Tom. XLVII. and the voyage of M. Gentil. I. 241.

† See Velleius Paterculus and Justin.

also come down to us from the Jews and Greeks, which they had derived variously from the Chaldeans, the Persians, and the Indians; and it is a most remarkable circumstance, that all these nations form only one original race, resembling each other in their physiognomies, and even in many conventional matters, such as their divinities, the names of the constellations, and even in the roots of their languages.*

The Hindoos, perhaps the most anciently civilized people on the face of the earth, and who have least deviated from their originally established forms, have unfortunately no history. Among an infinite number of books of mystical theology and abstruse metaphysics, they do not possess a single volume that is capable of affording any distinct account of their origin, or of the various events that have occurred to their communities. Their *Maha-Bharata*, or pretended great history, is nothing more than a poem. The *Pouranas* are mere legends; on comparing which with the Greek and Latin authors, it is excessively difficult to es-

* For the analogy of the languages of India, Persia, and our western world, see the Mithridates of Adelung. On the analogy of the deities of the Indians, Egyptians, Greeks, and Romans, consult the works of Jablonsky and Gatterer, already cited; as also the Memoir of Sir William Jones, with the notes of M. Langlès, in the first volume of the French translation of the Calcutta Memoirs, p. 192, *et seq.* The identity of the constellations, especially of the signs of the Zodiac, between the Hindoos and the most western nations, with the names given to the days of the week, &c. are now universally known.

tablish a few slight coincidences of chronology, and even that is continually broken off and interrupted, and never goes back farther than the time of Alexander.*

It is now clearly proved that their famous astronomical tables, from which it has been attempted to assign a prodigious antiquity to the Hindoos, have been calculated backwards;† and it has been lately ascertained, that their *Surya-Siddhanta*, which they consider as their most ancient astronomical treatise, and pretend to have been revealed to their nation more than two millions of years ago, must have been composed within the seven hundred and fifty years last past.‡ Their *Vedas*, or sacred books, judging from the calendars which are conjoined with them, and by which they are guided in their religious observances, and estimating the *colures* indicated in these calendars, may perhaps go back about three thousand two hundred years, which nearly coincides with the epoch of Moses.§ Yet the Hindoos are not entirely ignorant of the re-

---

* Consult the elaborate Memoir of M. Paterson, respecting the kings of Magadaha, emperors of Hindostan, and upon the epochs of Vicramadityia and Salahanna, in the Calcutta Memoirs, vol. IX.

† See Expos. du Syst. du Monde, by M. de la Place, p. 330.

‡ See the Memoir by M. Bentley, on the Antiquity of the Surya-Siddhanta, in the Calcutta Memoirs, vol. VI. p. 537, and the Memoir by the same Author on the Astronomical Systems of the Hindoos, *ibid.* vol. IX. p. 195.

§ See the Memoir by M. Colebrooke upon the Vedas, and particularly p. 493, in the Calcutta Memoirs, vol. VIII.

volutions which have affected the globe, as their theology has in some measure consecrated certain successive destructions which its surface has already undergone, and is still doomed to experience; and they only carry back the last of those, which have already happened, about five thousand years;* besides which, one of these revolutions is described in terms nearly corresponding with the account given by Moses.† It is also very remarkable, that the epoch at which they fix the commencement of the reigns of their first human sovereigns, of the race of the Sun and Moon, is nearly the same at which the ancient authors of the west have placed the origin of the Assyrian monarchy, or about four thousand years ago.

---

* Voyage to India by M. Le Gentil, I. 235.—Bentley in the Calcutta Memoirs, vol. IX. p. 222.—Paterson, in ditto. *ibid.* p. 86.

† Sir William Jones, in the Calcutta Memoirs, French translation, vol. I. p. 170.

The English reader may be gratified by the following extract from this dissertation of Sir William Jones.—*Transl.*

"We may fix the time of Buddah, or the ninth great incarnation of Vishnu, in the year 1014 before the birth of Christ. The Cashmirians, who boast of his descent in their kingdom, assert that he appeared on earth about two centuries after Crishna, the Indian Apollo............... We have therefore determined another interesting epoch, by fixing the age of Crishna near the year 1214, before Christ. As the three first *avatars* or descents of Vishnu, relate no less clearly to an *Universal Deluge*, in which eight persons only were saved, than the fourth and fifth do to the punishment of impiety and the humiliation of the proud; we may for the present assume that the second, or silver age of the Hindus, was subsequent to the dispersion from Babel; so that we have only a dark interval of about a thousand years, which were employed in the settlement of nations, and the cultivation of civilized society."—*Works of Sir William Jones*, I. 29, 4to. *London*, 1799.

It were quite in vain to attempt looking for any indications of these great events among the people of more southern regions, such as the Arabians or Abyssinians, as their ancient books are no longer existing; and the only histories they possess relative to remote antiquity are of recent compilation, and have been modelled after our Bible: hence all that their books contain respecting the deluge is borrowed from Genesis, and does not contribute any support to its authority. The Guebres, however, or Parsis, who are now the sole depositories of the doctrines of Zoroaster and the ancient Persians, speaks also of an universal deluge as having happened before the reign of *Cayoumarats*, their first king.

In order to recover some truly historical traces of the last grand *cataclysma*, or universal deluge, we must go beyond the vast deserts of Tartary, where, in the north-east of our ancient continent, we meet with a race of men differing entirely from us, as much in their manners and customs, as they do in their form and constitution. Their oral language is entirely monosyllabic, and they use arbitrary hieroglyphics instead of writing. They only possess a system of political morals, without any established religion; as the superstitions of the sect of Fo have been imported by them from India. Their yellow skins, high cheek-bones, narrow and oblique eyes, and thinly scattered beards, give them an appearance so entirely different from us,

that one is almost tempted to suspect that their ancestors and ours had escaped from the last grand catastrophe at two different sides: but, however this may have been, they date their deluge nearly at the same period with ours.

The *Chou-King*,* the most ancient of the Chinese books, is said to have been compiled by Confucius, about two thousand five hundred years ago, from fragments of more ancient works. Two hundred years afterwards, under the Emperor Chi-hoang-ti, the men of letters were persecuted, and all books were destroyed. About forty years after this persecution, an old *literati* restored a portion of the *Chou King* from memory, and another portion was recovered that had been concealed in a tomb; but nearly the half was lost for ever. This, which is considered as the most authentic of all the Chinese books, begins the history of the country with an emperor named *Yao*, whom it represents as having let loose the waters, in the following terms: *Having raised himself to heaven, Yao bathed the feet even of the highest mountains, covered the less elevated hills, and rendered the plains impassable.* According to some accounts, the reign of Yao was four thousand five hundred years ago; while others only carry it back to three thousand nine hundred and thirty years before the present time.

* See the preface to the translation of the Chou-King, by M. de Guignes.

The same book, only a few pages farther on, introduces one *Yu*, prime minister and chief engineer, re-establishing the courses of the rivers, building dikes, digging canals, and regulating the taxes of all the provinces of China, that is, of an empire which extends six hundred leagues in all directions. But the utter impossibility of such operations, immediately after such events, shows clearly that the whole story can only be considered as a moral and political romance.

More modern Chinese historians have introduced a long series of emperors before Yao, which they have combined with a multitude of fabulous circumstances, yet without venturing to assign any fixed dates to their reigns. These writers also continually differ from each other, both in the number and names of the kings; and none of them are universally approved on this subject by their countrymen.

The introduction of astronomy into China is attributed to Yao; but the real eclipses recorded by Confucius, in his Chronicle of the Kingdom of *Lou*, only go back two thousand six hundred years, hardly half a century higher than those of the Chaldeans, as related by Ptolemy. In the *Chou-King* indeed, there is an eclipse mentioned which goes back three thousand nine hundred and sixty-five years, but which is related with the addition of so many absurd circumstances, that it has been

probably invented at a subsequent period. A conjunction also is stated as having happened four thousand two hundred and fifty-nine years ago, which would therefore be the most ancient known astronomical observation, but its authenticity is contested. The earliest observation that appears to rest upon good grounds, is one made by means of a gnomon, two thousand nine hundred years ago.

It is not to be conceived that mere chance should have thus given rise to so striking a coincidence between the traditions of the Assyrians, the Hindoos, and the Chinese, in attributing the origins of their respective monarchies so nearly to the same epoch, of about four thousand years before the present day. The ideas of these three nations, which have so few features of resemblance, or rather which are so entirely dissimilar in language, religion, and laws, could not have so exactly agreed on this point, unless it had been founded upon truth.

We do not require any specific dates from the natives of America, who were not possessed of any real writing, and whose most ancient traditions only go back a few centuries before the arrival of the Spaniards. Yet even among them some traces of a deluge are conceived to have been found in their barbarous hieroglyphics.*

* See the excellent and magnificent work of Humboldt, upon the monuments of the Mexicans.

The Negroes, the most degraded race among men, whose forms approach nearest to those of the inferior animals, and whose intellect has not yet arrived at the establishment of any regular form of government, nor at anything which has the least appearance of systematic knowledge, have preserved no sort of annals or of tradition; and from them therefore we are not to expect any information on the subject of our present researches. Yet even the circumstances of their character clearly evince that they also have escaped from the last grand catastrophe, perhaps by another route than the races of the caucassan and altaic chains, from whom perhaps they may have been long separated before the epoch of that catastrophe.

Thus all the nations which possess any records or ancient traditions, uniformly declare that they have been recently renewed, after a grand revolution in nature. This concurrence of historical and traditionary testimonies, respecting a comparatively recent renewal of the human race, and their agreement with the proofs that are furnished by the operations of nature, which have been already considered, might certainly warrant us in refraining from the examination of certain equivocal monuments, which have been brought forward by some authors in support of a contrary opinion.[*] But even this examination, to judge of it by some attempts already made, will probably do nothing

else than add some more proofs to that which is furnished by tradition.

§ 33. *Proofs derived from several Micellaneous Consideration.*

It does not now appear that the famous zodiac in the porch of the temple at Dendera, can support the opinion which some have been disposed to deduce from it, respecting the high antiquity of the present race of mankind. Nothing can be drawn for this purpose, from its division into two bands of six signs each, as indicative of the position of the colures produced by the precession of the equinoxes, or to show that these do not merely answer to the commencement of the civil year of the Egyptians at the period when it was drawn. As the civil year in Egypt consisted exactly of three hundred and sixty-five days, it made the tour of the zodiac in fifteen hundred and eight years; or, according to the Egyptians, which shows that they had not observed it in fourteen hundred and sixty years. In the same temple there is another zodiac, in which the sign *Virgo* is represented as beginning the year. If these circumstances were connected with the position of the solstice, this other zodiac in the interior of the temple must have been drawn two thousand years before that in the porch; but supposing it to represent the commencement of the civil year, an interval of very little more than a hundred years is

quite sufficient to reconcile the two zodiacs with each other.

It may be inquired also, whether our zodiac may not contain some internal proofs of its antiquity, and whether the figures which have been employed to represent its signs or constellations, may not have some reference to the colures at the epoch when they were adopted. All, however, that has been advanced on this subject, is founded on allegories, supposed to be contained in the several figures. Thus it has been supposed, that *Libra*, or the balance, indicated the equality of the days and nights; *Taurus*, or the bull, the season of labouring the earth; *Cancer*, or the crab, a retrogradation of the sun; *Virgo*, the season of gathering in the fruits of the earth; and so of the rest. All this is mere bold conjecture: But besides, these explanations must necessarily vary for every country; and it would be requisite to assign a different epoch to each separate zodiac, according to the climate of the country in which it is supposed to have been invented; nay, perhaps, there may be no climate and no epoch in conformity with which rational explanations could be devised for all the signs. It is also possible, that these names may have been given at a very remote period, without reference at all to the divisions of time or space, or to the different states of the sun in its course, just as they are now given by astronomers; and may have been applied to the constellations or

groups of stars, as referring to a particular epoch merely by chance; so that nothing whatever can be deduced from their significations.*

It may be objected, that the advanced state of astronomy among these ancients is a striking proof of their high antiquity, and that it must have required a vast many centuries of observations by the Chaldeans and Indians to enable them to acquire the knowledge which they certainly possessed nearly three thousand years ago, respecting the length of the year, the precession of the equinoxes, the relative motions of the sun and moon, and several other important circumstances. But to explain all this, without the necessity of any prodigious antiquity, it may be remarked, that a nation may well be expected to make rapid progress in any particular science that has no other to attend to; and that with the Chaldeans especially, the perpetual serenity and clearness of their sky, the pastoral life which they led,† and the peculiar su-

* See the dissertation by M. de Guignes respecting the zodiacs of the oriental nations, in the Memoirs of the Academy of Belles Lettres, vol. XLVII.

† It may be here noticed, that our present shepherds have infinitely more practical knowledge of astronomy, merely from being so much in the open air, almost unemployed, than all the other ordinary ranks in society. An instance of astonishingly rapid progress in that science was exhibited in our own day by the celebrated James Ferguson, who constructed an accurate map of the heavens when a herd-boy, entirely from his own untutored genius. Had astronomy been then a nonexistent science, even he might have carried it almost as far as the Chaldeans in a single lifetime; and perhaps, in mapping the heavens he went farther even than all the astronomers of Chaldea.—*Transl.*

perstition to which they were addicted, rendered the stars a general object of attention. They had also colleges, or societies of their most respectable men, appointed to make astronomical observations, and to put them upon record. Let us suppose, also, that among so many persons who had nothing else to do, there were two or three possessed of singular talents for the study of geometrical science, and every thing known to that people might easily have been accomplished in a very few centuries.

Since the time of the Chaldeans, real astronomy has only had two eras; that of the Alexandrian school, which lasted four centuries, and that of our own times, which had not yet lasted so long. The learned period of the Arabs hardly added anything to that science, and all the other ages of the world were mere blanks with respect to it. Three hundred years did not intervene between Copernicus and De la Place, the celebrated author of the *Mécanique Céleste;* yet some wish to believe. that the Hindoos must have had many thousand years to discover their astronomical rules. After all, even were every thing that has been fancied respecting the antiquity of astronomy as fully proved as it appears to us destitute of proof, it would establish no conclusion against the great catastrophe, which has left in other respects so many convincing monuments of its own existence. All that it is necessary to admit, even on that sup-

position, is, what some moderns have thought,—That astronomy was among the number of the sciences that were preserved by the small number of men who escaped from that catastrophe.

The antiquity of certain mining operations has also been prodigiously exaggerated by some writers. A recent writer pretends that the mines of the island of Elba, to judge from their wastes, must have been explored above forty thousand years ago; while another author, who has also examined these wastes with much attention, reduces the interval to somewhat more than five thousand years, supposing that the ancients wrought out every year one-fourth only of the quantity that is wrought out in the present day.* We have no reason, however, to believe that the Romans, who consumed so much iron in their armies, were so slow in their mining operations as this high antiquity of the mines of Elba would imply; and besides, even if these mines had been wrought for no more than four thousand years, how should it have been that iron was so little known among the ancients in the first ages of Greece and Rome?

§ 34. *Concluding Reflections.*

I am of opinion, then, with M. Deluc and M.

---

* See History of China, before the Deluge of the Ogigians, by M. de Fortin d'Urban, II. 33.

Dolomieu,—That, if there is any circumstance thoroughly established in geology, it is, that the crust of our globe has been subjected to a great and sudden revolution, the epoch of which cannot be dated much farther back than five or six thousand years ago; that this revolution had buried all the countries which were before inhabited by men and by the other animals that are now best known; that the same revolution had laid dry the bed of the last ocean, which now forms all the countries at present inhabited; that the small number of individuals of men and other animals that escaped from the effects of that great revolution, have since propagated and spread over the lands then newly laid dry; and consequently, that the human race has only resumed a progressive state of improvement since that epoch, by forming established societies, raising monuments, collecting natural facts, and constructing systems of science and of learning.

Yet farther,—That the countries which are now inhabited, and which were laid dry by this last revolution, had been formerly inhabited at a more remote era, if not by man, at least by land animals; that, consequently, at least one previous revolution had submerged them under the waters; and that, judging from the different orders of animals of which we discover the remains in a fossil state,

they had probably experienced two or three irruptions of the sea.

These alternate revolutions form, in my opinion, the problem in geology that is most important to be solved, or rather to be accurately defined and circumscribed; for, in order to solve it satisfactorily and entirely, it were requisite that we should discover the cause of these events,—an enterprise involving difficulties of a very different nature.

We are able to discover with sufficient precision all that takes place on the surface of our world in its present state, and we have sufficiently ascertained the uniform progress and regular successions of the primitive formations; but the study of the secondary formations is as yet scarcely commenced. The wonderful series of unknown marine moluscæ and zoophites, followed by fossil remains of serpents and of fresh-water fish, equally unknown, which are again succeeded by other moluscæ and zoophites more nearly allied to those which exist at present: All these land animals, these moluscæ, and other unknown animals of fresh water, which next occupy the formations, and which are finally succeeded by other moluscæ and other animals resembling those of our present seas; the relations between these various animals and the plants whose remains are mixed among them, and the relations of both with the mineral strata

in which they are imbedded; the little resemblance between these extraneous fossils of animals and plants, as contained in the different basins of former waters:—All these form a series of phenomena which imperiously demands the attention of philosophers.

This study is rendered interesting, by the variety of productions of partial or general revolutions which it affords, and by the abundance of the different species which alternately offer themselves to view; it neither has that dull monotony which attaches to the study of the primitive formations, nor does it force us, like the latter, almost necessarily into hypotheses. The facts with which it is conversant are so prominent, so curious, and so obvious, that they may suffice to occupy the most ardent imagination; and the conclusions which they afford from time to time, even to the most cautious observer, have nothing vague or arbitrary in their nature. Finally, by the careful investigation of these events, which approach, as it were, to the history of our own race, we may hope to be able to discover some traces of more ancient events and their causes; if, after so many abortive attempts already made on the same subject, we may yet flatter ourselves with that hope.

These ideas have haunted, and I may even say, have tormented me, during all my researches into the fossil remains of bones, of which I now offer the

results to the public; and though these only contain a very small portion of the phenomena connected with the immediately preceding period of the history of the earth, they yet connect themselves most intimately with the rest. It was hardly possible to avoid endeavouring to examine these phenomena in the country immediately round Paris; and my excellent friend M. Brongniart, led by other studies to have similar views, associated himself with me in the investigation, by which we laid the foundation of our Essay on the Mineral Geography of Paris. That work, however, although it bears my name, has become almost entirely the work of my friend, in consequence of the infinite care he has bestowed, ever since the first conception of our plan, and during the execution of our several surveys and researches, in the thorough investigation of all the objects of our research, and in the composition of the Essay itself.

The Essay on the Mineral Geography of the Environs of Paris, affords the most complete and satisfactory evidences of the principal facts and circumstances which I have endeavoured to establish in this discourse. It contains a history of the most recent changes which have taken place in one particular basin, and leads us as far as the chalk formation, which is infinitely more extended over the globe than the formations composed of those materials which are found in the basin of Paris. The chalk formation, which was before

conceived to be of very modern origin, has been shown in that extensive examination to have originated at a period considerably far back in the age before the last; or, in other words, to have owed its origin to causes connected with the revolution and catastrophe before the last general irruption of the waters over our present habitable world.

It would now be of great importance to examine the other basins containing chalk formations, and in general to pay particular attention to the strata which rest upon that formation, that these may be compared with those we found in the environs of Paris. Perhaps the chalk itself may be found to contain some successive depositions of organic remains. It is surrounded and supported by the compact limestone, which occupies a great proportion of France and Germany, and the extraneous fossils of which are extremely different from all those of our basin. But, in following the compact limestone, from the chalk to the limestone of the central ridges of Jura, which are almost devoid of shells, or to the aggregated rocks of the acclivities of the Hartz, the Vosges, and the Black Forest, we shall probably find abundance of variations: And the gryphites, the cornua ammonis, and the entrochi, with which it abounds, may perhaps be found distributed by genera, or at least by species.

This compact limestone formation is not everywhere covered over by chalk. Without that intervening, it surrounds basins in several places, or supports elevated flats or table lands not less worthy of examination than those which are limited by chalk. We should derive great information, for instance, from a history of the gypsum quarries of Aix, in which, as well as in those of Paris, reptiles and fresh-water fishes are found; and probably land-animals will be also discovered by careful research; while we are assured that nothing similar occurs in the entire interval between these two places, which are almost two hundred leagues distant from each other.

The long ranges of sand-hills which skirt both slopes of the Appenines through almost the entire length of Italy, contain everywhere perfectly well-preserved shells, which are often found retaining their colours, and even their natural pearl-like polish, and several of which resemble those still found in our seas. It would be of great importance to be well acquainted with these, and to have all their successive strata accurately examined, determining the extraneous fossils found in each, and comparing them with those that are contained in other recent strata; such, for example, as those in the environs of Paris.

In the course of this investigation, it would be proper to connect the series, on the one hand, with

the most solid and most ancient formations, and on the other, with the recent alluvial depositions made by the Po, the Arno, and their tributary streams; as also, to determine their relations with the innumerable masses of volcanic productions which are interposed between them; and, finally, to ascertain the mutual situations of the various sorts of shells, and of the fossil bones of elephants, rhinoceroses, hippopotami, whales, cachalots, and dolphins, in which several of these hills abound. I have only a very superficial knowledge of these lower hills of the Appenine chain, acquired in the course of a journey devoted to other objects; but I am of opinion that they contain the true secret of the last operations of the sea.

There are many other strata, even celebrated for their extraneous fossils, which have not been hitherto so accurately examined as to enable them to be connected with the general series, and whose relative antiquity, therefore, has not been ascertained. The copper slate of Thuringia* is said to be filled with the remains of fresh-water fish, and to be older than most of the secondary or flœtz formations. We are also as yet uninformed of the real position of the stinkstone slate of Oeningen, which is also said to be full of the remains of fresh-water fish; of that of Verona, evidently abounding in the remains of sea-fish, but which

* Bituminous marl slate.—Jameson's Mineralogy, vol. ii. p. 197.

have been very improperly named by the naturalists who have described them; of the black slate of Glacis; of the white slate of Aichstedt, also filled with the remains of fishes, of crabs, and of other marine animals different from shells. All these desiderata have as yet received no satisfactory explanation in books of geology; neither has it been as yet explained, why shells should be found almost everywhere, while fish are confined only to a few places.

It appears to me, that a consecutive history of such singular deposits would be infinitely more valuable than so many contradictory conjectures respecting the first origin of the world and other planets, and respecting phenomena which have confessedly no resemblance whatever to those of the present physical state of the world; such conjectures finding, in these hypothetical facts, neither materials to build upon, nor any means of verification whatever. Several of our geologists resemble those historians who take no interest in the history of France, except as to what passed before the time of Julius Cæsar. Their imaginations, of course, must supply the place of authentic documents; and accordingly each composes his romance according to his own fancy. What would become of these historians, if they had not been assisted in their combinations by the knowledge of posterior facts? But our geologists neglect exactly those posterior geological facts, which might, at least in

some measure, dispel the darkness of the preceding times.

It would certainly be exceedingly satisfactory to have the fossil organic productions arranged in chronological order, in the same manner as we now have the principal mineral substances. By this the science of organization itself would be improved; the developements of animal life; the succession of its forms; the precise determinations of those which have been first called into existence; the simultaneous production of certain species, and their gradual extinction;—all these would perhaps instruct us fully as much in the essence of organization, as all the experiments that we shall ever be able to make upon living animals: And man, to whom only a short space of time is allotted upon the earth, would have the glory of restoring the history of thousands of ages which preceded the existence of the race, and of thousands of animals that never were contemporaneous with his species.

END OF THE ESSAY.

SUPPLEMENT:

Being an Extract from the Researches of M. de Prony, on the Hydraulic System of Italy: Containing an Account of the Displacement of that Part of the Coast of the Adriatic which is occupied by the Mouths of the Po.

THAT portion of the shore of the Adriatic which lies between the lake, or rather *lagune*, of Commachio and the *lagunes* of Venice, has undergone considerable alterations since ancient times, as is attested by authors worthy of entire credit, and as is still evidenced by the actual state of the soil in the districts near the coast; but it is impossible now to give any exact detail of the successive progress of these changes, and more especially of their precise measures, during the ages which preceded the twelfth century of our era.

We are, however, certain, that the city of *Hatria*, now called *Adria*, was formerly situated on

the edge of the coast; and by this we attain a known fixed point upon the primitive shore, whence the nearest part of the present coast, at the mouth of the Adige, is at the distance of 25,000 *metres*;* and it will be seen in the sequel, that the extreme point of the alluvial promontory, formed by the Po, is farther advanced into the sea than the mouth of the Adige by nearly 10,000 metres.†

The inhabitants of Adria have formed exaggerated pretensions, in many respects, as to the high antiquity of their city, though it is undeniably one of the most ancient in Italy, as it gave name to the sea which once washed its walls. By some researches made in its interior and its environs, a stratum of earth has been found mixed with fragments of Etruscan pottery, and with nothing whatever of Roman manufacture. Etruscan and Roman pottery are found mixed together in a superior bed, on the top of which the vestiges of a theatre have been discovered. Both of these beds are far below the level of the present soil. I have seen at Adria very curious collections, in which these re-

---

* Equal to 27,340 yards and 10 inches English measure, or 15 1-2 miles and 60 yards.

In these reductions of the revolutionary French *metres* to English measure, the *metre* is assumed as 39.37 English inches.—*Transl.*

† Or 10,936 yards and 4 inches, equal to 6 miles and nearly a quarter, English measure.

Hence the entire advance of the alluvial promontory of the Po appears to have extended to 21 miles 5 furlongs and 216 yards.—*Transl.*

mains of antiquity are separately classed; and having some years ago observed to the viceroy, that it would be of great importance, both to history and geology, to make a thorough search into these buried remains at Adria, carefully noticing the levels in comparison with the sea, both of the primitive soil, and of the successive alluvial beds, his highness entered warmly into my ideas; but I know not whether these propositions have been since carried into effect.

Following the coast, after leaving Hatria, which was situated at the bottom of a small bay or gulf, we find to the south a branch of the *Athesis* or Adige, and of the *Fossa Philistina*, of which the remaining trace corresponds to what might have been the Mincio and Tartaro united, if the Po had still run to the south of Ferrara. We next find the *Delta Venetum*, which seems to have occupied the place where the lake or lagune of Commachio is now situated. This delta was traversed by seven branches of the *Eridanus* or Po, formerly called also the *Vadis Padus* or *Podincus:* which river, at the diramification of these seven branches, and upon its left or northern bank, had a city named *Trigoboli*, whose site could not be far from where Ferrara now stands. Seven lakes, enclosed within this delta, were called *Septem Maria*, and Hatria was sometimes denominated *Urbs Septum Marium*, or the city of the seven seas or lakes.

Following the coast from Hatria to the northwards, we come to the principal mouth of the *Athesis* or Adige, formerly named *Fossa Philistina*, and afterwards *Estuarium Altini*, an interior sea, separated, by a range of small islands, from the Adriatic gulf, in the middle of which was a cluster of other small isles, called *Rialtum*, and upon this archipelago the city of Venice is now seated. The *Estuarium Altini* is what is now called the lagune of Venice, and no longer communicates with the sea, except by five passages, the small islands of the archipelago having been united into a continuous dike.

To the east of the lagunes, and north from the city of Este, we find the *Euganian* mounts, or hills, forming, in the midst of a vast alluvial plain, a remarkable isolated group of rounded hillocks, near which spot the fable of the ancients supposes the fall of Phæton to have taken place. Some writers have supposed that this fable may have originated from the fall of some vast masses of inflamed matters near the mouths of the Eridanus, that had been thrown up by a volcanic explosion; and it is certain that abundance of volcanic products are found in the neighbourhood of Padua and Verona.

The most ancient notices that I have been able to procure respecting the situation of the shores of the Adriatic at the mouths of the Po, only begin to be precise in the twelfth century. At that epoch

the whole waters of this river flowed to the south of Ferrara, in the *Po de Volano* and the *Po di Primaro*, branches which enclosed the space occupied by the *lagune* of Commachio. The two branches which were next formed by an irruption of the waters of the Po to the north of Ferrara, were named the river of *Corbolo*, *Langola*, or *Mazzorno*, and the river *Toi*. The former, and more northern of these, received the *Tartaro*, or *canal bianco*, near the sea, and the latter was joined at Ariano by another branch derived from the Po, called the *Goro* river. The sea-coast was evidently directed from south to north, at the distance of ten or eleven thousand *metres** from the meridian of Adria; and *Loreo*, to the north of *Mesola*, was only about 2000 *metres*† from the coast.

Towards the middle of the twelfth century, the flood waters of the Po were retained on their left or northern side by dikes near the small city of *Ficarolo*, which is about 19,000 *metres*‡ to the northwest of Ferrara, spreading themselves southwards over the northern part of the territory of Ferrara and the *Polesine* of Rovigo, and flowed through the two formerly-mentioned canals of *Mazzorno* and *Toi*. It seems perfectly ascertained, that this change in the direction of the waters of the Po

* Equal to 10,936 or 12,030 yards English measure.—*Transl.*

† Or 2,186 yards 2 feet English.—*Transl.*

‡ Or 20,778 yards 1 foot 10 inches.—*Transl.*

had been produced by the effects of human labours; and the historians who have recorded this remarkable fact only differ from each other in some of the more minute details. The tendency of the river to flow in the new channels, which had been opened for the more ready discharge of its waters when in flood, continually increased; owing to which the two ancient chief branches, the *Voalno* and *Primaro*, rapidly decreased, and were reduced in less than a century to their present comparatively insignificant size; while the main direction of the river was established between the mouth of the Adige to the north, and what is now called *Porto di Goro* on the south. The two before-mentioned canals of *Mazzorno* and *Toi*, becoming insufficient for the discharge, others were dug; and the principal mouth, called *Bocco Tramontana*, or the northern mouth, having approached the mouth of the Adige, the Venetians became alarmed in 1604; when they excavated a new canal of discharge, named *Taglio de Porto Viro*, or *Po delle Fornaci*, by which means the *Bocco Maestra* was diverted from the Adige towards the south.

During four centuries, from the end of the twelfth to that of the sixteenth, the alluvial formations of the Po gained considerably upon the sea. The northern mouth, which had usurped the situation of the *Mazzarno* canal, becoming the *Ramo di Tramontana*, had advanced in 1600 to the distance

of 20,000 *metres** from the meridian of Adria; and the southern mouth, which had taken possession of the canal of *Toi*, was then 17,000 *metres*† advanced beyond the same point. Thus the shore had become extended nine or ten thousand *metres*‡ to the north, and six or seven thousand to the south.§ Between these two mouths there was formerly a bay, or a part of the coast less advanced than the rest, called *Sacca di Goro*. During the same period of four hundred years previous to the commencement of the seventeenth century, the great and extensive embankments of the Po were constructed; and also, during the same period, the southern slopes of the Alps began to be cleared and cultivated.

The great canal, denominated *Taglio di Porto Viro*, or *Podelle Fornaci*, ascertains the advance of the alluvial depositions in the vast promontory now formed by the mouths or delta of the Po. In proportion as their entrances into the sea extend from the original land, the yearly quantity of alluvial depositions increases in an alarming degree, owing to the diminished slope of the streams, which was a necessary consequence of the prolongation of their bed, to the confinement of the waters between dikes, and to the facility with

* Or 21,872 yards.—*Transl.*
† Or 18,591 yards.—*Transl.*
‡ Equal to 9,842 or 10,936 yards.—*Transl.*
§ Equal to 6,564 or 7,655 yards—*Transl.*

which the increased cultivation of the ground enabled the mountain torrents which flowed into them to carry away the soil. Owing to these causes, the bay called *Sacca di Goro* was very soon filled up, and the two promontories which had been formed by the two former principal mouths of *Mazzorno* and *Toi*, were united into one vast projecting cape, the most advanced point of which is now 32,000 or 33,000 *metres** beyond the meridian of Adria: so that in the course of two hundred years, the mouths or delta of the Po have gained about 14,000 *metres*† upon the sea.

From these facts, of which I have given a brief enumeration, the following results are clearly established.

First,—That at some ancient period, the precise date of which cannot be now ascertained, the waves of the Adriatic washed the walls of Adria.

Secondly,—That in the twelfth century, before a passage had been opened for the waters of the Po at *Ficarolo*, on its left or northern bank, the shore had been already removed to the distance of nine or ten thousand *metres*‡ from Adria.

---

* From 19 miles 7 furlongs and 15 yards, to 20 miles 4 furlongs and 9 yards, English measure.—*Transl.*

† Or 15,366 yards.—*Transl.*

‡ Equal to 9,842 or 10,936 yards.—*Transl.*

Thirdly,—The extremities of the promontories formed by the two principal branches of the Po, before the excavation of the *Taglio di Porto Viro*, had extended by the year 1600, or in four hundred years, to a medium distance of 18,500 *metres** beyond Adria; giving, from the year 1200, an average yearly increase of the alluvial land of 25 *metres*.†

Fourthly,—That the extreme point of the present single promontory, formed by the alluvions of the existing branches, is advanced to between thirty-two and thirty-three thousand *metres*‡ beyond Adria; whence the average yearly progress is about seventy *metres*§ during the last two hundred years, being greatly more rapid in proportion than in former times.

---

* Or 20,231 yards.—*Transl.*

† Exactly 27 yards 1 foot and 1-4th of an inch English.—*Transl.*

‡ Already stated at from 19 3-4 to 20 1-2 miles; or more precisely, from 34,995 yards 1 foot 8 inches, to 36,089 yards 10 inches English measure.—*Transl.*

§ Equal to 76 yards 1 foot 7 inches and 9-10ths.

APPENDIX,

CONTAINING

MINERALOGICAL NOTES,

AND AN ACCOUNT OF

CUVIER'S GEOLOGICAL DISCOVERIES.

NOTES.

Note A. § 4. p. 30.

On the Subsidence of Strata.

M. Cuvier adopts the opinion of De Luc, that all the older strata of which the crust of the earth is composed, were originally in an horizontal situation, and have been raised into their present highly-inclined position, by subsidences that have taken place over the whole surface of the earth.

It cannot be doubted, that subsidences, to a considerable extent, have taken place; yet we are not of opinion, that these have been so general as maintained by these geologists. We are rather inclined to believe, that the present inclined position of strata is in general their original one;—an opinion which is countenanced by the known mode of connexion of strata, the phenomena of veins, particularly cotemporaneous veins, the crystalline nature of every species of older rock, and the great regularity in the *direction* of strata throughout the globe.

The transition and flœtz-rocks also are much more of a chemical or crystalline nature than has been generally

imagined. Even sandstone, one of the most abundant of the flœtz-rocks, occasionally occurs in masses, many yards in extent, which individually have a tabular or stratified structure: but when viewed on the great scale, appear to be great massive distinct concretions. These massive concretions, with their subordinate tabular structures, if not carefully investigated, are apt to bewilder the mineralogist, and to force him to have recourse to a general system of subsidence or elevation of the strata, in order to explain the phenomena they exhibit.

Note B. § 7. p. 39 & 41.
On Primitive Rocks.

As the enumeration of primitive mountain rocks in the text is incomplete, we have judged it useful to give in this note a more full account of them. Primitive mountains, in general, form the highest and most rugged portions of the earth's surface, and extend in the form of chains of mountain-groups throughout the whole earth. These mountain-groups are generally highest in the middle, and lowest towards the sides and extremities; and the mountain-rocks of which they are composed, are so arranged, that in general the middle and highest portions of the group are composed of older rocks than the lateral and lower portions. As far as we know at present, granite is the oldest and first formed of all the primitive rocks. This rock is composed of felspar, quartz, and mica, and varies in its structure from coarse to very small granular. It sometimes alternates with beds of quartz and felspar, and is often traversed by cotemporaneous veins of granite, of quartz, and of felspar. The newer or upper portions of the formation contain cotemporaneous masses of porphyry, syenite, hornblende rock, limestone, &c. It frequently

forms the highest, and at the same time the central part of mountain-groups. The next rock, in point of antiquity, or that which rests immediately upon the granite, is gneiss, which has a distinct slaty structure, is stratified, and, like granite, is composed of felspar, quartz, and mica. It alternates with the newer portions of the granite, and sometimes cotemporaneous veins of the one rock shoot into masses of the other. It contains subordinate formations of granite, porphyry, syenite, trap, quartz, limestone, and conglomerated gneiss. The next rock in the series is mica-slate, which rests upon the gneiss. It is composed of quartz and mica, and has a distinct slaty structure, and is stratified. It alternates with gneiss, and contains various subordinate formations, as granite, porphyry, syenite, trap, quartz, serpentine, limestone, and conglomerated mica-slate. It is often traversed by cotemporaneous veins, from the smallest discernible magnitude to many yards in width. The mica-slate is succeeded by clay-slate, which rests upon it, and sometimes alternates with it. It differs from mica-slate, gneiss, and granite, in its composition, being in general a simple rock; and in some instances principally composed of mica, in others to all appearance of felspar. Besides granite, porphyry, trap, syenite, limestone, serpentine, conglomerated clay-slate,* quartz, it also contains the following formations; flinty-slate, whet-slate, talk-slate, alum-slate, and drawing-slate. The calcarious rocks mentioned by Cuvier, as resting upon the slate, do not belong to this class; they are transi-

* The primitive conglomerated rocks, mentioned as above, as occurring in gneiss, mica-slate, and clay-slate, are sometimes named greywacke.

tion limestone, and contain, although rarely, testaceous petrifactions.

NOTE C. § 7. p. 42.

Crystallized Marbles resting on shelly Strata.

M. Cuvier says, "the crystallized marbles never cover the shelly strata." This observation is not perfectly correct; for transition limestone, and certain magnesian flœtz limestones, which are to be considered as crystallized marbles, contain testaceous petrifactions, and alternate with other strata that contain petrified shells.

Crystallized marble, or granular foliated limestone, occur, along with flœtz trap rocks, in the coal formation, in different parts of Scotland, as upon the Lomonds, in Fifeshire, &c.

NOTE D. § 7. p. 43.

Rolled Masses upon the Mountains of Jura.

Numerous large blocks, or masses of mountain rocks, are met with in almost every country of Europe, and frequently very far removed from their original situations. Switzerland and the surrounding countries present numerous and very interesting appearances of this kind. On the mountains of Jura, immediately in the line of direction of the Vallais, and nearly to the height of 6000 feet, enormous blocks of granite are found resting upon the limestone rocks of that range of mountains. These blocks are of that species of granite which forms the mountain of Ornex, belonging to the group of Mont Blanc; hence it is inferred that they must have been transported by the force of water from that region to their present situation.

Masses of conglomerate also occur upon the Jura mountains, of the same varieties as those which occur in fixed rocks at Valorsine, and other places in the vicinity of Mont Blanc. Blocks of greywacke and of black limestone are amongst the rolled blocks, and these also can be traced as fixed rocks in the Vallais.

Many phenomena of the same description are to be observed in Scotland. It would be an interesting and valuable addition to the geology of Great Britain, to have a map constructed representing the distribution of these blocks over the whole surface of the island.

NOTE E. § 9. p. 46.
Salisbury Craigs.

The front of Salisbury craigs, near Edinburgh, affords a fine example of the natural chronometer, described in the text. The acclivity is covered with loose masses that have fallen from the hill itself; and the quantity of debris is in proportion to the time which has elapsed since the waters of the ocean formerly covered the neighbouring country. If a vast period of time had elapsed since the surface of the earth had assumed its present aspect, it is evident, that long ere now the whole of this hill would have been enveloped in its own debris. We have here, then, a proof of the comparatively short period since the waters left the surface of the globe,—a period not exceeding a few thousand years.

NOTE F. § 10. p. 46.
On the Alluvial Land of the Danish Islands in the Baltic, and on the Coast of Sleswick.

In this section, Cuvier gives a clear and distinct account of several kinds of alluvial formations. M. De Luc, in the first volume of his Geological Travels, de-

scribes the alluvial formations that cover and bound many of the islands in the Baltic and upon the coast of Denmark, and gives so interesting an account of the modes followed by the inhabitants in preserving these alluvial deposites, that we feel pleasure in communicating it to our readers.

During my stay at Husum, I had the advantage of passing my evenings very agreeably and profitably at the house of M. Hartz, with his own family, and two Danish officers, Major Behmann, commandant at Husum, and Captain Baron de Barackow. The conversation often turned on the objects of my excursions, and particularly on the natural history of the *coasts* and of the *islands;* respecting which M. Hartz obligingly undertook to give me extracts from the chronicles of the country. This led us to speak of the Danish islands; and those officers giving me such descriptions of them as were very interesting to my object, I begged their permission to write down in their presence the principal circumstances which they communicated to me. These will form the first addition to my own observations; I shall afterwards proceed to the information which I obtained from M. Hartz.

The two principal islands of the Danish Archipelago, those of Funen and Seeland (or Zeland), as well as some small islands in the Kattegate, namely, Lenoe, Anholt, and Samsoe, are hilly, and principally composed of *geest;** and in these are found *gravel* and *blocks of granite,* and of

---

* By *geest* is understood the alluvial matter which is spread over the surface both of the hilly and low country, and appears to have been formed the last time the waters of the ocean stood over the surface of the earth.—J.

other stones of that class, exactly in the same manner as in the country which I have lately described, and its *islands* in the North Sea. On the borders of the two first of these Danish islands, there are also *blocks* in the sea; but only in front of *abrupt* coasts, as is the case with the islands of Poel and Rugen, and along the coasts of the Baltic. The lands added to these islands of *geest* are in most part composed of the *sand* of the sea, the land-waters there being very inconsiderable; and to the south of them have been formed several islands of the same nature, the chief of which are Laland and Falster, near Seeland. These, like the *marsch* islands in the North Sea, are sand-banks accumulated by the waves, and, when covered with grass, continuing to be farther raised by the sediments deposited between its blades. In the Baltic, where there are no sensible tides, such islands may be inhabited without dikes, as well as the extensions of the coasts; because, being raised to the highest level of that sea, while their declivity under water is very small, and being also more firm in their composition, the waves die away on their shores; and if, in any extraordinary case, the sea rises over them, it leaves on them fresh deposits, which increase their heights. These soils are all perfectly *horizontal*, like those added to the coasts of the continent.

Some of these islands approach entirely or in part to the nature of that of Rugen. This island of Seeland, on that side which is called Hedding, has a promontory composed of strata of *chalk* with its flints. The island of Moen, (or Mona,) on the south of the latter, has a similar promontory near Maglebye and Mandemark; and the island of Bornholm, the easternmost of those belonging to Denmark, contains strata of *coal*, covered by others of *sandstone*. Phenomena like these, evident symptoms

of the most violent catastrophes at the bottom of the ancient sea, proceeding, as I think I have clearly shown, from the subsidence and angular motions of large masses of strata, which must have forced out the interior fluids with the utmost impetuosity, it is not surprising that so many fragments of the lowermost strata are found dispersed over this great theatre of ruins.

I now proceed to the details which I received from M. Hartz; beginning by a specific designation of the *islands* dependent on the province of Sleswigh, such as they are at present, belonging to the three classes already defined. To commence from the north; Fanoe, Rom, Sylt, and Amrom, were originally *islands* of the same nature as the neighbouring continent, but have been since extended by *marsches*.* The soil of these islands, with its gravel and blocks of primordial stones, was at first barren, as the *geest* is naturally every where; but is become fertile by manure, of which there has been no deficiency, since those grounds have been surrounded with *marsch*, where the cattle are kept in stables during the winter. In the island of Sylt, there are spaces consisting of *moor;* but its head of land, which extends on the south as far as Mornum, is composed entirely of *marsch*, and is bordered with *dunes* towards the open sea, because, the sediments of the rivers not reaching any farther, the *sea-sand* impelled against it by the waves remains pure, and is thus raised by the winds in hillocks on the shore. The shallow bottom of the sea, between this island and that of Fora, is of *geest:* at low water, it

* By *marsch* is understood the new land added to the coasts since the last retiring of the water of the globe from the surface of the earth, and is formed by the sediments of rivers, mixed more or less with sand from the bottom of the sea.—J.

may be passed over on foot; and there are found on it gravel and blocks of *granite*. But on the same side of Fora there is a great extent of *marsch*, beginning from St. Laurencius. Among the islands consisting entirely of *marsch* and surrounded with dikes, the most considerable are Pellworm and Nord Strand; and among the Halligs, or those inhabited without dikes, the chief are Olant, Nord-marsh, Langne, Groode, and Hooge.

Such are the islands on this coast, in their present state, now rendered permanent by the degree of perfection at which the art of dike-making is arrived. But, in former times, though the *original* land was never attacked by the *sea*, which, by adding to it *new lands*, soon formed a barrier against its own encroachments, the latter, and the *islands* composed of the same materials, were subject to great and sudden changes, very fatal to those who are engaged to settle on them by the richness of their soil, comparatively with the continental. The inhabitants, who continued to multiply on them during several generations, were taught, indeed, by experience, that they might at last be invaded by the element which was incessantly threatening them; but having as yet no knowledge of natural causes, they blindly considered those that endangered them as supernatural, and for a long time used no precautions for their own security. They were ignorant of the dreadful effects of a certain association of circumstances, rare indeed, but, when occurring, absolutely destructive of these *marsches*. This association consists of an extraordinary elevation of the level of the North Sea, from the long continuance of certain winds in the Atlantic, with a violent storm occurring during the tides of the new or full moon; for then the sea rises above the level of all the *marsches;* and before they were secured against such attacks, the waves rolling over them,

and tearing away the grass which had bound their surface, they were reduced to the state of mere banks of sand and mud, whence they had been drawn, by the long course of ordinary causes. Such were the dreadful accidents to which the first settlers on these lands were exposed; but no sooner were they over, than ordinary causes began again to act; the sand-banks rose; their surface was covered with grass; the coast was thus extended, and new islands were formed; time effaced the impression of past misfortunes; and those among the inhabitants of these dangerous soils, who had been able to save themselves on the coast, ventured to return to settle on them again, and had time to multiply, before the recurrence of the same catastrophes.

This has been the general course of events on all the coasts of the North Sea, and particularly on those of the countries of Sleswigh and Holstein. It is thus that the origin and progress of the *art of dikes* will supply us with a very interesting *chronometer* in the history of the continent and of man, particularly exemplified in this part of the globe. A Lutheran clergyman, settled in the island of Nord Strand, having collected all the particulars of this history which the documents of the country could afford, published it in 1668, in a German work, entitled *The North Frisian Chronicle.* It was chiefly from this work, and from the *Chronicle of Dankwerth,* that M. Hartz extracted the information which he gave to me, accompanied by two maps, copied for me, by one of his sons, from those of Johannes Mayerus, a mathematician; they bear the title of *Frisia Cimbrica ;* one of them respecting the state of the *islands* and of the *coast,* in 1240, as it may be traced in the chronicles, and the other, as it was in 1651.

According to these documents, the first inhabitants of the *marsches* were *Frisii* or *Frisians*, designated also under the names of *Cimbri* and *Sikambri:* the latter name, M. Hartz conjectures, might come from the ancient German words *Seekampfers*, i. e. *Sea-warriors*; the *Frisians* being very warlike. These people appear to have had the same origin with those, who, at a rather earlier period, took possession of the *marsches* of Ost-Frise, (East-Friesland,) and of that Friesland which forms one of the United Provinces; but this common origin is very obscure. Even at the present day, the inhabitants of the *marsches*, from near Husum to Tondern, or Tunder to the North, though themselves unacquainted with it, speak a language which the other inhabitants of the country do not understand, and which is supposed to be Frisian. It is the same at a village in the peninsula of Bremen, by which I have had occasion to pass.

The *Sicambri* or *North Frisians*, are traced back to some centuries before the Christian era. At the commencement of that era, they were attacked by Frotho, King of Denmark, and lost a battle, under their king Vicho, near the river Hever. Four centuries afterwards they joined the troops of Hengist and Horsa. In the year 692, their king Radebot resided in the island of Heiligeland. Charles Martel subdued them in 732; and some time afterwards, they joined Charlemagne against Gottric, King of Denmark. These are some of the circumstances of the history of this Frisian colony, recorded in the chronicles of which I have spoken; but the history here interesting to us is that of the lands whereon they settled.

It appears that these people did not arrive here in one body, but successively, in the course of many years: they spread themselves over various parts of the coasts of the

North Sea, and even a considerable way up the borders of the Weser and the Elbe; according to documents which I have mentioned in my *Lettres sur l'Histoire de la Terre et de l'Homme*. These new settlers found large *marsches*, formed, as well in the wide mouths of those rivers as along the coasts, and around the original islands of *geest;* especially that of Heiligeland, the most distant from the coast, and opposite the mouth of the Eyder. Of this island, which is steep towards the south, the original mass consists of strata of *sandstone;* and at that time its *marsch* extended almost to Eyderstede: there were *marsches* likewise around all the other original islands; besides very large islands of pure *marsch* in the intervals of the former.

All these lands were desert at the arrival of the Frisians; and the parts on which they established their first habitations, to take care of their breeds of horses and cattle feeding on the *marsches*, were the original eminences of the islands; on that of Heiligeland they built a temple to their great goddess Phoseta, or Fosta. When they became too numerous to confine themselves to the heights, their herds being also greatly multiplied, they ventured to begin inhabiting the *marsches;* but afterwards, some great inundations having shown them the dangers of that situation, they adopted the practice followed by those who had settled on the *marsches* of the province of Groningen, and still continued on the Haligs; that of raising artificial mounts called *werfs*, on which they built their houses, and whither they could, upon occasion, withdraw their herds; and it likewise appears that, in the winter, they assembled in greater numbers on the spots originally the highest, in the islands, as well as on some parts of the coasts.

Things continued in this state for several centuries; during which period, it is probable that the inhabitants of these lands were often, by various catastrophes, disturbed in the enjoyment of them, though not discouraged. But in 516, by which time these people were become very numerous, more than 600 of them perished by one of the concurrences of fatal circumstances already defined. It was then that they undertook the astonishing enterprise of enclosing these lands. They dug ditches around all the *marsches*, heaping up on their exterior edge the earth which was taken out; and thus they opposed to the sea, dikes of eight feet in height. After this, comprehending that nothing could contribute more to the safety of their dwellings, than to remove the sea to a greater distance, they undertook, with that view, to exclude it from the intervals between the islands, by uniting, as far as should be possible, those islands with each other. I will describe the process by which they effected this, after I shall have recalled to attention some circumstances leading to it.

From all that I have already said of the *fore-lands*, and of the manner in which they are increased, it may be understood, that the common effects of the *waves* and of the *tides* is to bring materials from the bottom of the sea towards the coasts; and that the process continues in every state of the sea. The land winds produce no *waves* on the coasts, which carry back to the bottom of the sea what has been brought thence by the winds blowing against the shore; and as for the *tides*, it may have been already comprehended, (and shall soon by proved,) that the *ebb* carries back but very little of what has been brought by the *flood*. So that, but for some extraordinary circumstances, the materials continually impelled towards the shore, which first form islands, would at last unite against

the coast in a continuous soil. The rare events, productive of great catastrophes, do not carry back these materials towards the bottom of the sea; they only, as it has been said before, ravage the surface, diminishing the heights, and destroying the effect of vegetation. These then were the effects, against which it was necessary to guard.

I now come to the plan of uniting the *islands* formed by these early inhabitants. They availed themselves for that purpose of all such parts of the sand-banks as lay in the intervals between the large islands, and were beginning to produce grass. These, when surrounded with dikes, are what are called *Hoogs;* and their effects are to break the waves, thus diminishing their action against the dikes of the large islands, and at the same time to determine the accumulation of the mud in the intervals between those islands. In this manner a large *marsch* island, named Everschop, was already, in 987, united to Eyderstede by the point on which Poppenbull is situated; and in 995, the union of the same *marsches* was effected by another point, namely that of Tetenbull. Lastly, in the year 1000, Eyderstede received a new increase by the course of the Hever, prolonged between the sand-banks, being fixed by a dike; but the whole still remained an *island*. This is an example, of the manner in which the *marsch islands* were united by the *hoogs;* and the chronicle of the country says, that by these labours the islands were so considerably enlarged in size, and the intervals between them so much raised, that at low water it was possible to pass on foot from one to the other. The extent of these *marsches* was so great on the coast of Sleswigh alone, that they were divided into three provinces, two of which comprehended the *islands*, and the third comprised the *marsches* contiguous to the coast; and the same

works were carried on upon the *marsches* of the coast of Holstein.

But the grounds thus gained from the *sand banks* were very insecure; these people, though they had inhabited them more than ten centuries, had not yet understood the possibility of that combination of fatal circumstances above described against which their *dikes* formed but a very feeble rampart; the North Sea, by the extraordinary elevations of its level, being much more formidable in this respect than the ocean, where the changes of absolute level are much less considerable. I shall give an abridged account of the particulars extracted by M. Hartz from the chronicle of Dankwerth, relative to the great catastrophes which these *marsches* successively underwent, previously to the time when experience led to the means necessary for their security.

In 1075, the island of Nord Strand, then contiguous to the coast, particularly experienced the effect of that unusual combination of defective causes; the sea passing over its dike, and forming within it large excavations like lakes. In 1114 and 1158, considerable parts of Eyderstede were carried away; and in 1204, the part called Sudhever in the *marsch* of Utholm was destroyed. All these catastrophes were fatal to many of the *marsch* settlers; but in 1216, the sea having risen so high that its waves passed over Nord Strand, Eyderstede, and Ditmarsch, near 10,000 of their inhabitants perished. Again, in 1300, seven parishes in Nord Strand and Pellworm were destroyed; and in 1338, Ditmarsch experienced a new catastrophe, which swept away a great part of it on the side next Eyderstede: the dike of the course of the Eyder between the sand-banks was demolished, and the tides have ever since preserved their

course throughout that wide space. Lastly, in the year 1362, the isles of Fora and Sylt, then forming but one, were divided, and Nord Strand, then a *marsch* united to the coast, was separated from it.

During a long time, the inhabitants who survived these catastrophes, and their successors, were so much discouraged, that they attempted nothing more than to surround with *dikes* like the former such spaces of their meadow-land as appeared the least exposed to these ravages, leaving the rest to its fate. But the common course of causes continually tending to extend and to raise the grassy parts of the sand-banks, and no extraordinary combination of circumstances having interrupted these natural operations, later generations, farther advanced in the arts, undertook to secure to themselves the possession of those new grounds. In 1525, they turned their attention to the indentations made, during the preceding catastrophes, in the borders of the *marsches*; the waves, confined in these narrow spaces, sometimes threatening to cut their way into the interior part. In the front of all the creeks of this kind they planted stakes, which they interlaced with osiers, leaving a certain space between the lines. The waves, thus broken, could no longer do injury to the *marsch*; and their sediments being deposited on both sides of this open fence, very solid *fore-lands* were there formed. In 1550, they raised the *dikes* considerably higher, employing wheelbarrows, the use of which was only then introduced. For this purpose they much enlarged and deepened the interior canals, in order to obtain more earth, not merely to add to the height of the dikes, but to extend their base on the outer side. At last they began to cover these dikes with straw ropes; but this great preservative of dikes was at first ill managed; and the use of it was so slowly

spread, that it was not adopted in Nord Strand and in Eyderstede, till about the years 1610 and 1612.

Before that time, however, the safety of the extensive soil of the latter *marsch* had been provided for in a different manner. I have said above, that, when the isles of Everschop and Utholm had been united to it, the whole together still formed but one large *island;* now, in this state, it was in as great danger on the side towards the continent, as on that open to the sea; because two small rivers, the Trene and the Nord Eyder, discharging themselves into the interval between it and the land, and by preserving their course to the sea, this interval was thus kept open to the tempests, sometimes from the side of the Hever; sometimes from that of the Eyder; and the waves, beating against the *geest*, were thence repelled upon the *marsch*. The inhabitants, seeing that the expense of remedying these evils would be greater than they could afford, while at the same time it was indispensable to their safety, addressed themselves to their bishops and to their prefect, of whom they requested pecuniary assistance; and having obtained it, they first undertook the great enterprise of carrying the Trene and the Nord Eyder higher up into the Eyder; keeping their waters, however, still separate for a certain space, by a *dam* with a *sluice*, in order to form there a reservoir of fresh water: the tides ascending up the Eyder above Frederichstadt. They were thus enabled to carry on the extremities of the *dike* on both sides to join the *geest;* and the interval between the latter and the *marsch* was then soon filled up, there being only left, at their junction, the canal above described, which receives the waters of the *geest*, and, at low water, discharges them from both its extremities by sluices. At the same time, the islands of Pellworm and Nord

Strand were united with each other by means of eight *hoogs;* and the *sandy marsches* of which I have spoken, contiguous to the *geest*, on the north of that of Husum, were enclosed with dikes.

After the dikes had been thus elevated, and their surface rendered firm by the straw ropes, though the latter were not yet properly fixed, the inhabitants of the *marsches* for some time enjoyed repose; but on the 11th October, 1634, the sea, rising to an excessive height, carried away, during the great tempest, the *hoogs* which had produced the junction between Pellworm and Nord Strand, these having ever since continued distinct islands; it also violently attacked Ditmarsch; and its ravages extended over the whole coast, as far as the very extensive new lands of Jutland. Princes then came forward zealously to the relief of their subjects. In particular, Frederic III., Duke of Sleswigh, seeing that the inhabitants of Nord Strand were deficient both in the talents and in the means necessary for the reparation and future security of that large island, and knowing that the art of dikes had made greater progress in Holland, because of the opulence of the country, addressed himself to the States General, requesting them to send him an engineer of dikes with workmen accustomed to repair them; and this was granted. The dikes of Nord Strand were then repaired in the most solid manner; and the Dutch engineer, seeing the fertility of its soil, advised his sons upon his death-bed, to purchase lands and settle there, if the duke would grant them the free exercise of their religion; they being Jansenist catholics, and the inhabitants of the island Lutherans. The duke agreed to this, on condition that they and their posterity should continue to superintend the works carried on upon the dikes; to which they engaged themselves. From that time the art of dikes, and particularly that part

of it which consists in covering them solidly with straw, has become common to all the *marsches;* and the Dutch families, which have contributed to this fortunate change, continue to inhabit the same island, and to enjoy the free exercise of their religion.

Note G. § 11. p. 48.
On the Sand Flood.

In different parts of Scotland, as in Aberdeenshire, Morayshire, Hebrides, and Shetland Islands, there are examples of the natural chronometer, mentioned in the text. One of the most striking examples I at present recollect of this phenomenon in foreign countries, is that described by M. De Luc's brother, in the *Mercure de France,* for September, 1807.

The *sands* of the Lybian desert, he says, driven by the west winds, have left no lands capable of tillage on any parts of the western banks of the Nile not sheltered by mountains. The encroachment of these *sands* on soils which were formerly inhabited and cultivated is evidently seen. M. Denon informs us, in the account of his *Travels in Lower and Upper Egypt,* that summits of the *ruins* of ancient *cities* buried under these *sands* still appear externally; and that, but for a ridge of mountains called the *Lybian chain,* which borders the left bank of the Nile, and forms, in the parts where it rises, a barrier against the invasion of these *sands,* the shores of the river, on that side, would long since have ceased to be habitable. Nothing can be more melancholy, says this traveller, than to walk over villages swallowed up by the sand of the desert, to trample under foot their roofs, to strike against the summits of their minarets, to reflect that yonder were cultivated fields, that

there grew trees, that here were even the dwellings of men, and that all has vanished.

If then our *continents* were as *ancient* as has been pretended, no traces of the habitation of men would appear on any part of the western bank of the Nile, which is exposed to this scourge of the *sands* of the desert. The existence, therefore, of such monuments attests the successive progress of the encroachments of the sand; and these parts of the bank, formerly inhabited, will for ever remain arid and waste. Thus the great population of Egypt, announced by the vast and numerous ruins of its cities, was in great part due to a cause of fertility which no longer exists, and to which sufficient attention has not been given. The *sands* of the desert were formerly remote from Egypt; the *Oases*, or habitable spots, still appearing in the midst of the sands, being the remains of the soils formerly extending the whole way to the Nile; but these *sands*, transported hither by the western winds, have overwhelmed and buried this extensive tract, and doomed to sterility a land which was once remarkable for its fruitfulness.

It is therefore not solely to her revolutions and changes of sovereigns that Egypt owes the loss of her ancient splendour; it is also to her having been thus irrecoverably deprived of a tract of land, by which, before the *sands* of the desert had covered it and caused it to disappear, her wants had been abundantly supplied. Now, if we fix our attention on this fact, and reflect on the consequences which would have attended it if thousands, or only some hundreds of centuries had elapsed since our continents first existed above the level of the sea, does it not evidently appear that all the country on the west of the Nile would have been buried under this *sand* before

the erection of the cities of ancient Egypt, how *remote* soever that period may be supposed; and that, in a country so long afflicted with sterility, no idea would even have been formed of constructing such vast and numerous edifices? When these cities indeed were built, another cause concurred in favouring their prosperity. The navigation of the Red Sea was not then attended with any danger on the coasts: all its ports, now nearly blocked up with *reefs of coral*, had a safe and easy access; the vessels laden with merchandise and provisions could enter them and depart without risk of being wrecked on these shoals, which have risen since that time, and are still increasing in extent.

The defects of the present government of Egypt, and the discovery of the passage from Europe to India round the Cape of Good Hope, are therefore not the only causes of the present state of decline of this country. If the *sands* of the desert had not invaded the bordering lands on the west, if the work of the *sea polypi* in the Red Sea had not rendered dangerous the access to its coasts and to its ports, and even filled up some of the latter, the population of Egypt and the adjacent countries, together with their product, would alone have sufficed to maintain them in a state of prosperity and abundance. But now, though the passage to India by the Cape of Good Hope should cease to exist, though the political advantages which Egypt enjoyed during the brilliant period of Thebes and Memphis should be reestablished, she could never again attain the same degree of splendour.

Thus the *reefs* of *coral* which had been raised in the Red Sea on the east of Egypt, and the *sands* of the desert which invade it on the west, concur in attesting this

truth: That our continents are not of a more remote *antiquity* than has been assigned to them by the sacred historian in the book of Genesis, from the great era of the Deluge.

Note H. § 12. p. 50.

Action of the Sea upon Coasts.

The ocean, in its action upon the cliffs and banks situated on the coasts, break them down to a greater or less extent, and either accumulates the debris at their basis in the form of sea breaches of greater or less magnitude, or by currents carries it away to be deposited upon other shores, or to give rise to sand-banks near the coast, which, in the course of time, became united to the land, and thus secures it from the further action of the sea. These *destroying* and *forming* effects of the waters of the ocean are to be observed all around the coasts of this island; and beautiful examples of such actions are to be seen on the coasts of Ireland, and in many of the islands that lie on the west and north of Great Britain. In a paper read before the Wernerian Natural History Society, Mr. Stevenson, engineer, mentions many facts illustrative of the destroying effects of the ocean on our coasts.—Thus he informs us that the waters of the sea are wearing away the land upon both sides of the Frith of Forth, not only in exposed, but also in sheltered situations, and the solid strata, as well as the looser alluvial formations, which owe their origin to the destroying agency of the ocean at a former period, are again yielding to its action. At Saint Andrews, the famous castle of Cardinal Beatoun, which is said originally to have been some distance from the sea, now almost overhangs it: From St. Andrews northward to Eden water and the River Tay, the coast presents a sandy beach, and is so liable to shift, that it is difficult to trace

the change it may have undergone. It is certain, however, that within this last century, the sea has made such an impression upon the sands of Barrey, on the northern side of the Tay, that the light-houses at the entrance of the river, which were formerly erected at the southern extremity of Button-ness, have been from time to time removed about a mile and a quarter further northward, on account of the wasting and shifting of these sandy shores, and that the spot on which the outer light-house stood in the 17th century, is now two or three fathoms under water, and is at least three quarters of a mile within flood mark.

At the ancient town of Burghhead, to the north of the Spey, an old fort or establishment of the Danes, was built upon a sandstone cliff, which tradition says, had a very considerable tract of land beyond it; but is now washed by the waves, and overhangs the sea. The old town of Findhorn was destroyed by the sea, and the site of it is now overflowed by every tide. At Fort George, some of the projecting bastions, formerly at a distance from the sea, are now in danger of being undermined by the water.

In Orkney, the Start-Point of Sanday, which is now formed into an island every flood tide, was even in the recollection of some old people still alive, one continuous tract of firm ground; but at present, the channel between Sanday and the Start *Island*, as it is now called, is hardly left by the water in neap tides; and since a light-house was erected upon this point about ten years ago, the channel appears to have been worn down at least two feet. Similar destroying effects of the water of the ocean are observed on the coasts of England.

§ 15. p. 51.

On Coral Islands.

Of all the genera of lythophytes, the madrepore is the most abundant. It occurs most frequently in tropical countries, and decreases in number and variety as we approach the poles. It encircles in prodigious rocks and vast reefs many of the basaltic and other rocky islands in the South Sea and Indian Ocean, and by its daily growth adds to their magnitude. The coasts of the islands in the West Indies, also those of the islands on the east coast of Africa, and the shores and shoals of the Red Sea, are encircled and incrusted with rocks of coral. Several different species of madrepore contribute to form these coral reefs; but by far the most abundant is the muricated madrepore, madrepora muricata of Linnæus. These lithophytic animals not only add to the magnitude of land already existing, but, as Cuvier remarks, they form whole islands. Dr. Forster, in his Observations made during a Voyage round the World, gives a curious account of the formation of these coral islands in the South Sea.

All the low isles, he says, seems to me to be a production of the sea, or rather its inhabitants, the polype-like animals forming the lithophytes. These animalcules raise their habitation gradually from a small base, always spreading more and more, in proportion as the structure grows higher. The materials are a kind of lime mixed with some animal substance. I have seen these large structures in all stages, and of various extent. Near Turtle Island, we found, at a few miles distance, and to leeward of it, a considerable large circular reef, over which the sea broke every where, and no part of it was above water; it included a large deep lagoon. To the east and north-east

of the Society Isles, are great many isles, which, in some parts, are above water; in others, the elevated parts are connected by reefs, some of which are dry at low water, and others are constantly under water. The elevated parts consist of a soil formed by a sand of shells and coral rocks, mixed with a light black mould, produced from putrefied vegetables, and the dung of sea-fowls; and are commonly covered by cocoa-nut trees and other shrubs, and a few antiscorbutic plants. The lower parts have only a few shrubs and the above plants; others still lower, are washed by the sea at high water. All these isles are connected, and include a lagoon in the middle, which is full of the finest fish; and sometimes there is an opening, admitting a boat or canoe in the reef, but I never saw or heard of an opening that would admit a ship.

The reef, or the first origin of these isles, is formed by the animalcules inhabiting the lithophytes. They raise their habitation within a little of the surface of the sea, which gradually throws shells, weeds, sand, small bits of corals, and other things, on the tops of these coral rocks, and at last fairly raises them above water; where the above things continue to be accumulated by the sea, till by a bird, or by the sea, a few seeds of plants, that commonly grow on the sea-shore, are thrown up, and begin to vegetate; and by their annual decay and reproduction from seeds, create a little mould, yearly accumulated by the mixture with sand, increasing the dry spot on every side; till another sea happens to carry a cocoa-nut hither, which preserves its vegetative power a long time in the sea, and therefore will soon begin to grow on this soil, especially as it thrives equally in all kinds of soil; and thus may all these low isles have become covered with the finest cocoa-nut trees.

The animalcules forming these reefs, went to shelter their habitation from the impetuosity of the winds, and the power and rage of the ocean; but as, within the tropics, the winds blow commonly from one quarter, they, by instinct, endeavour to stretch only a ledge, within which is a lagoon, which is certainly entirely screened against the power of both: this therefore might account for the method employed by the animalcules in building only narrow ledges of coral rocks, to secure in their middle a calm and sheltered place: and this seems to me to be the most probable cause of THE ORIGIN of all THE TROPICAL LOW ISLES, over the whole South Sea.

That excellent navigator, the late Captain Flinders, gives the following interesting account of the formation of Coral Islands, particularly of Half-way Island on the north coast of Terra Australis:*

This little island, or rather the surrounding reef, which is three or four miles long, affords shelter from the southeast winds; and being at a moderate day's run from Murray's Isles, it forms a convenient anchorage for the night to a ship passing through Torres' Strait: I named it *Half-way Island*. It is scarcely more than a mile in circumference, but appears to be increasing both in elevation and extent. At no very distant period of time, it was one of those banks produced by the washing up of sand and broken coral, of which most reefs afford instances, and those of Torres' Strait a great many. These banks are in different stages of progress: some, like this, are become islands, but not yet habitable; some are above high water mark, but destitute of vege-

* Vol. II. p. 114, 115, 116.

tation; whilst others are overflowed with every returning tide.

It seems to me, that when the animalcules, which form the corals at the bottom of the ocean, cease to live, their structures adhere to each other, by virtue either of the glutinous remains within, or of some property in salt water; and the interstices being gradually filled up with sand and broken pieces of coral washed by the sea, which also adhere, a mass of rock is at length formed. Future races of these animalcules erect their habitations upon the rising bank, and die in their turn to increase, but principally to elevate, this monument of their wonderful labours. The care taken to work perpendicularly in the early stages, would mark a surprising instinct in these diminutive creatures. Their wall of coral for the most part, in situations where the winds are constant, being arrived at the surface, affords a shelter, to leeward of which their infant colonies may be safely sent forth; and to this their instinctive foresight it seems to be owing, that the windward side of a reef exposed to the open sea, is generally, if not always, the highest part, and rises almost perpendicular, sometimes from the depth of 200, and perhaps many more fathoms. To be constantly covered with water, seems necessary to the existence of the animalcules, for they do not work, except in holes upon the reef, beyond low water mark; but the coral sand and other broken remnants thrown up by the sea, adhere to the rock, and form a solid mass with it, as high as the common tides reach. That elevation surpassed, the future remnants, being rarely covered, lose their adhesive property; and remaining in a loose state, form what is usually called a *key*, upon the top of the reef. The new bank is not long in being visited by sea birds; salt plants, take root upon it, and a soil begins to be formed; a co-

coa-nut, or the drupe of a pandanus, is thrown on shore; land birds visit it, and deposit the seeds of shrubs and trees; every high tide, and still more every gale, adds something to the bank; the form of an island is gradually assumed; and last of all comes man to take possession.

Half-way Island is well advanced in the above progressive state; having been many years, probably some ages, above the reach of the highest spring tides, or the wash of the surf in the heaviest gales. I distinguished, however, in the rock which forms its basis, the sand, coral, and shells, formerly thrown up, in a more or less perfect state of cohesion. Small pieces of wood, pumice stone, and other extraneous bodies which chance had mixed with the calcarious substances when the cohesion began, were enclosed in the rock; and in some cases were still separable from it without much force. The upper part of the island is a mixture of the same substances in a loose state, with a little vegetable soil; and is covered with the *casuarina* and a variety of other trees and shrubs, which give food to parroquets, pigeons, and some other birds; to whose ancestors, it is probable, the island was originally indebted for this vegetation.

Note K. § 16. p. 53.

On the Diminution of the Waters of the Ocean.

That the water of the ocean has diminished, and is still diminishing, can scarcely be doubted; yet the rate of decrease since the period of the deluge has been so gradual, being now effected not by the conversion of the water into the earthy materials of which the globe is composed, but principally by the agency of animals, vegetables, and volcanoes, that, on a general view, it may be said to be nearly imperceptible. The facts mentioned by Celsius and

others, in regard to the rapid diminution of the waters of the Baltic, have been much insisted on by some geologists, although they cannot correctly be employed in illustrating the supposed general diminution of the waters of the globe; because the Baltic is a nearly enclosed sea, receiving rivers of considerable magnitude. Professor Playfair, in his elegant geological work, remarks in regard to the diminution of the waters of the ocean:—

"If we proceed further to the north, to the shores of the *Baltic* for instance, we have undoubted evidence of a *change of level* in the same direction as on our own shores. The level of the sea has been represented as lowering at so great a rate as *forty inches in a century*. Celsius observed, that several rocks which are now above the water, were not long ago sunken rocks, and dangerous to navigators; and he took particular notice of one which in the year 1680, was on the surface of the water, and in the year 1731 was $20\frac{1}{2}$ Swedish inches above it. From an inscription near the *Aspo*, in the lake *Melar*, which communicates with the *Baltic*, engraved, as is supposed, about five centuries ago, the level of the sea appears to have sunk in that time no less than thirteen Swedish feet. All these facts, with many more which it is unnecessary to enumerate, make the *gradual depression*, not only of the *Baltic*, but of the whole *Northern Ocean*, a matter of certainty." —PLAYFAIR'S *Illustrations*, p. 445.

That indefatigable and accurate observer De Luc, has the following commentary on the preceding passage:—

"It would be unnecessary to mention even the two inconsiderable facts above, if the *depression* of the *level* of these *seas* were indeed *a matter of certainty;* for the best authenticated and the least equivocal monuments of their

change would then abound along all their coasts. But proofs are every where found that such a *change* is *chimerical :* they may be seen in all the *vales* coming down to these *seas*, in which there is no perceptible impression of the action of any *waters* but those of the *land*, and no vestige, through their whole extent, of any permanent abode of those of the *sea ;* and proofs to the same effect are equally visible, along the coasts of both these *seas*, in all the *new lands* which have been formed on them, and which, being perfectly *horizontal*, from the point where their formation commenced, evidently show that the *water* displaced by them has been constantly at the same *level*. Hence appears the necessity of multiplying, as I have done and shall continue to do, for the subversion of a prejudice of such ancient date, the examples of these peremptory proofs of its total want of foundation. The *rock* mentioned by Celsius had probably been observed by him at times when the *level* of the *sea* was different; its known differences much exceeding the quantity here specified. As for the inscription near Aspo, in a country abounding with *lakes* as much as that which I have above described, if we were acquainted with its terms, we should probably find it to be, like many which I have seen in various places along the course of the Oder and the Elbe, the monument of some extraordinary inundation of the land, from the sudden melting of the snows in the mountains, at a time when the water had been prevented from running off by an equally extraordinary rise of the level of the sea; of which the effects on low coasts may extend very far inland.

" By his conclusion, however, from these few facts, contrary to every thing observed on the coasts of this sea, Mr. Playfair thinks himself authorized to maintain that *the gradual depression, not only of the Baltic, but of the whole*

northern ocean, is a matter of certainty: afterwards he examines merely which of these two causes, the *subsidence* of the *sea* itself, or the *elevation* of the *land* around it, agrees the best with the phenomena; and he decides in favour of the latter, pointing out its accordance with the Huttonian Theory."

NOTE L. (A.) § 23.

Werner's Views of the Natural History of Petrifactions.

From the observation in section 22, Cuvier does not appear to have known how much Werner has done for the advancement of the natural history of fossil organic remains. He did not rest satisfied with the developement of the mere mineralogical branch of the theory of the earth; on the contrary, early in life he began to investigate the relations of all the classes of fossil organic remains, being well convinced, that without an accurate and comprehensive knowledge of these interesting bodies, geological speculation would have excited but comparatively little notice. Many years ago he embodied all that was known of petrifactions into a regular system. He insisted on the necessity of every geognostical cabinet containing, besides complete series of rocks for illustrating the mineralogical relations of the globe, an extensive collection not only of shells, but also of the various productions of the class zoophyta, of plants, particularly of sea plants and ferns; and an examination of the remains of quadrupeds in the great limestone caves and alluvial soils of Germany, soon pointed out to him the necessity of attaching to the geognostical cabinet also one of comparative osteology. As his views in geognosy enlarged, he saw more and more the value of a close and deep study of petrifactions. He first made the highly important observation, that different formations can be discriminated by the petrifactions they contain. It was

during the course of his geognostical investigations that he ascertained the general distribution of organic remains in the crust of the earth. He found that petrifactions appear first in transition rocks. These are but few in number, and of animals of the zoophytic or testaceous classes. In the older flœtz rocks they are of more perfect species, as of fish and amphibious animals; and in the newest flœtz and alluvial rocks, of birds and quadrupeds, or animals of the most perfect kinds. He always maintained that no fossil remains of the human species had been found in flœtz rocks, or in any of the older alluvial formations; but was of opinion that such remains might be discovered in the very newest of the alluvial depositions. He was also led to believe, from his numerous observations, that sea plants were of more ancient origin than land plants. A careful study of the genera and species of petrifactions disclosed to him another important fact, viz. that the petrifactions contained in the oldest rocks are very different from any of the species of the present time; that the newer the formation, the more do the remains approach in form to the organic beings of the present creation; and that in the very newest formations, fossil remains of the presently existing species occur. He also ascertained, that the petrifactions in the oldest rocks are much more mineralized than those in the newer rocks, and that in the newest rocks they are merely bleached or calcined. He found that some species of petrifaction were confined to particular beds; others were distributed throughout whole formations, and others seemed to occur in several different formations; the original species found in these formations appearing to have been so constituted as to live through a variety of changes which had destroyed hundreds of other species, which we find confined to particular beds.

Note M. § 23.

On the Distribution of Petrifactions in the different Classes of Rocks.

As an account of the distribution of fossil organic remains throughout the strata, of which the crust of the earth is composed, cannot fail to prove interesting, even to the general reader, we shall here give a very short sketch of what is known on the subject. Fossil organic remains, or petrifactions, have not hitherto been discovered in any of the primitive rocks; indeed it would appear that animals and vegetables were not called into existence until the period when the transition rocks began to be formed. Hence it is, that petrifactions have not been met with in any rock older than those of the transition class.

TRANSITION ROCKS.

The principal transition rocks are greywacke, greywacke slate, clay slate, limestone, greenstone, amygdaloid, syenite, porphyry, and granite. All of them do not afford petrifactions, these bodies having been hitherto found only in limestone, greywacke, greywacke slate, and clay slate.

1. *Transition Limestone.*

Fossil corallitic bodies, such as madreporites, tubiporites, and milleporites, of different species, abound in many varieties of this limestone. It is in general difficult to determine the species of these genera, owing to their being much intermixed with each other, and with the matter of limestone. On a general view, they certainly approach in external characters to those corals we at present meet within a living state in the tropical regions of the globe. Intermixed with these corals, or in separate strata, we find various species of orthoceratites, lituites,

ammonites, belemnites, nautilites, lenticulites, chamites, terebratulites, anomites, and patellites.

2. *Greywacke.*

This is a rock, including in a basis of quartzy clay slate, variously shaped masses of clay slate, greywacke slate, flinty slate, and sometimes also masses and grains of felspar, and scales of mica. It very rarely contains petrifactions. Hence in many extensive tracts of country where it predominates, not a single fossil organic remain is to be seen. The animal petrifactions which have been discovered in this rock are ammonites, and madreporites, of the same species as those met with in clay slate, and greywacke slate; also solenites, mytulites, tellinites, and large orthoceratites. The vegetable petrifactions are alleged to be fruits, stems and leaves of palm-like vegetables, and parts of reeds.

3. *Clay Slate.*

It rarely contains petrifactions; and the only kinds hitherto met with in it appear to be ammonites and trilobites.

4. *Greywacke Slate.*

This rock seldom contains petrifactions. Where it borders on the clay slate, it contains the same kinds of ammonites as occur in that rock, and in the vicinity of greywacke and transition limestone, we observe in it orthoceratites, corrallites, and fossil remains of reeds and marine plants. The orthoceratites gracilis of Blumenbach, the Molossus of Montfort, and also the coralliolites orthoceratoides, which are found in this rock, seem to belong to those remarkable corals that form a kind of connecting link between shells and corals. Particular beds of siliceous and ferruginous nature, subor-

dinate to the greywacke slate, abound more in petrifactions. They contain principally some species of madreporites; also screw-stones, (schraubensteine), which appear to be derived from the coralliolites epithonius, and whole families of terrebratulites, with a few species of turbinites, and striped chamites.

It appears from the preceding statement, that in general the different species of transition rocks contain similar petrifactions, and that they are principally distinguished by the number of corals and orthoceratites imbedded in them.

FLŒTZ ROCKS.

Fossil organic remains are much more abundant, and more varied in the rocks of this than of the preceding class. We shall enumerate the rocks of this class according to their relative antiquity, and begin with the lowest or first formed number of the series, which is named.

I. *First Sandstone, or Old Red Sandstone.*

This rock is characterized by its colour, composition, imbedded minerals, strata with which it is associated, the veins that traverse it, and its position in regard to the other rocks of which the crust of the earth is composed. It rests upon the transition rocks, and is very intimately connected with them, as transitions are to be observed from the one into the other. On a general view, it might be viewed as the newest member of the transition class, rather than the oldest of the flœtz rocks. The red sandstone contains but few petrifactions, and these are principally of trunks or branches of trees, some of which appear to resemble those of the tropical regions. The great coal formation sometimes rests upon this sandstone. In the

sandstone which is associated with the coal, and also in the slate clay with which it alternates, there frequently occur remains of common and of arborescent ferns, gigantic reeds, palms, and leaves of a tree which resembles the *casuarina*, and which was long considered as an *equisetum*. In the limestone, slate clay, &c. of the coal fields in this country, many petrifactions occur, such as orthoceratites, ammonites, nautilites, serpulites, patellites, helicites, turbites, buccinites, trochites, mytulites, cardites, anomites, pectinites, echinites, entrochites, and millepories. Bones and teeth of fishes are said to have been also found in the coal formation.

II. *First Flœtz Limestone.*

This limestone rests immediately on the first sandstone formation. It is divided into the following members: 1. Alpine limestone. 2. Bituminous marl slate. 3. Zechstein. 4. The coal subordinate to the formation in general.

1. *Alpine Limestone.**

This is the most highly crystallized limestone of the series. It is principally characterized by the ammonites and lenticulites it contains. In it we also meet with single coralliolites, encrinites, terebratulites, ostracites, buccinites, chamites, echinites, belemnites, and gryphites.

2. *Bituminous Marl Slate.*

This remarkable limestone is very widely distributed, and often contains abundance of petrified fishes, which

* This limestone appears to agree in many characters with the mountain or matalliferous limestone of England, and like that rock to rest sometimes upon old red sandstone, and sometimes upon greywacke. It is very intimately related to both these great formations.

are in general most numerous in those places where the rock occurs in basin-shaped strata. Many attempts have been made to determine the genera and species of these animals, but hitherto with little success. It would appear that the greater number are fresh-water species, and a few marine species. But the most remarkable fossil organic remain hitherto found in this limestone, is that of an animal of the genus monitor, of the class amphibia, of which Cuvier has given an interesting account in his great work on Fossil Organic Remains.

Petrifactions of vegetables rarely occur in this limestone; we sometimes meet with branches of plants analogous to the *lycopodium*, and more rarely fragments of *ferns*, and of plants allied to the genus *phalaris*.

Amongst these fresh-water productions, we meet with various fossil remains of marine animals, such as gryphites, pentacrinites, trilobites, and corallophites.

3. *Zechstein.*

This rock, in some of its characters, resembles the alpine limestone, but does not contain so many petrifactions. Ammonites occur in it; and pentacrinites fasciculosus, and whole families of gryphites aculeatus. It contains more rarely the gryphites rugosus, terebratulites alatus, terebratulites lacunosus, and probably also the terebratulites striatissimus, T. obliquus, and T. variabilis. It affords nearly the same species of milleporites and coralliolites as are found in the bituminous marl slate. It is worthy of remark, that nearly all the petrifactions found in this formation are much broken.

4. *Coal.*

Beds of coal occur in the zechstein, and also, according to some mineralogists, in the alpine limestone, ac-

companied with slate clay, bituminous slate, and other rocks, all of which frequently contain petrifactions of bivalve shells, and impressions of plants. The shells resemble those met with in the alpine limestone, and also in the Jura limestone; and the vegetable impressions are of lycopodiums and ferns, resembling those found in the old coal formation. But, besides these, we observe remains of plants of the palm tribe, some of which resemble the carica papaya, a native of Senegal.

III. *Second or variegated Sandstone Formation. Third Sandstone Formation.*

The second sandstone rests upon the first limestone and gypsum, and also upon coal,* but the position of the third sandstone has not been accurately ascertained. The following are some of the petrifactions mentioned by authors as occurring in them.

Encrinites trochitiferus. Schlottheim. Brunswick.
Dentalites striatus. Schlottheim. Mecklenburg.
Trochilites scheuchzeri. St. Gallen.
Turbinites torquatus. Knorr. Neufschatel.
regensbergensis. Knorr. Regenberg, near Blankenburg.
australis. Schlottheim. France.
Muricites volutinus. Bourg. T. 34. F. 223. St. Gallen.
nisus. Bourg. T. 34. F. 226. St. Gallen.
assimilis. Bourg. T. 24. F. 228. St. Gallen.
Bullites reticulatus. Bourg. T. 37. F. 240. St. Gallen.
senilis. Bourg. T. 37. F. 250. St. Gallen.
Pectinites punctatus. Volkm. Siles. subterr. T. 23 F. 3.

* In the lower parts of Dumfries-shire it rests upon the coal formation.

Pectinites radiatus. Id. T. 32. F. 6.
reticulatus. Id. T. 33. F. 1.
longicolli. Id. T. 33. F. 9.
anomalus. Id. T. 34. F. 13.
gigas. Knorr. P. II. 1. T. B. F. 1. 2. Ortenberg.
polonicus. Schlottheim. Wieliczka.
Chamites transversim punctatus. Volkm. Siles. subterr. T. 33. F. 7.
Ostracites labiatus. Knorr. P. II. 1. T. B. II. *b*** Fy. 2. Pirna.
Anomites paradoxus. Scheuchz. F. 96.
Pinnites diluvianus. Knorr. P. II. 1. T. D. X. F. 1. 2. Pirna.
Gryphites rugosus. Knorr. P. II. 1. T. B. 1. d. F. 7. Wieliczka.
Musculites sablonatus. Bourg. T. 23. F. 142. 143.
rugosus. Knorr. P. II. 1. T. B. vi. F. 3. Silesia.
Tellinites musculitiformis. Knorr, P. II. 1. T. B. II. St. Gallen.
margaritaceus. Schlottheim. Mecklenburg.

IV. *Second Flœtz Limestone, or Jura Limestone.*

This formation, which rests on the rocks of the second sandstone formation, and is remarkable for the abundance and variety of petrifactions it contains, includes beds of coal, marl, sand-stone, stink-stone, and probably also of gypsum. The petrifactions occur principally in the beds of marl, sand-stone and stink stone, and more sparingly in the other strata.

The following are the genera of petrifactions that have been met with in it:—Serpulites, asterialites, encrinites, echinites, orthoceratites, belemnites, ammonites, nauti-

lites, lenticulites, helicites, trochilites, buccinites, patellites, chamites, buccardites, donacites, venulites, ostracites, terebratulites, anomites, gryphites, musculites, and coralliolites. Some varieties contain petrified fishes of various genera and species, and also fossil amphibious animals. The vegetable petrifactions that occur in this formation are of stems and leaves, as those of the populus and rhamnus, and of flowers, as the ranunculus.

V. *Third Flœtz, or Shell Limestone.*

This formation is newer than either the second limestone or sandstone; and the following list contains the names of several of the petrifactions found in it.

Asteriatites eremita. Schlottheim. Gotha.
Encrinites trochitiferus. Blumenb. Abbild. F. 60.
Pentacrinites Gottingensis. Heimberg, near Gottingen.
Britannicus. Blum. Abbild. T. 70. F. *a. b.* Dorsetshire.*
Echinites ruralis. Schlottheim. Tonna.
Dentalites obsoletus. Schlottheim. Tonna.
Bitubulites problematicus. Bl. Abb. T. II. F. 9.
Belemnites paxillosus. Schlottheim. Heimberg, near Gottingen.
Ammonites nodosus. Mus. Tessin. T. 4. F. 3. Thuringia.
franconicus. Knorr. P. II. 1. A. 2. F. 1. Koburg.
margaritatus. Montf. Fol. 90. Antwerp.
amaltheus. Knorr. P. II. 1. T. A. II. F. 3. France.
planulites. Monf. F. 78.
dubius. Bourg. T. 39. F. 163.
spatosus. List. Anim. Angl. T. 6. F. 3. Gottingen.

* Does this really belong to the shell limestone?

Ammonites pusillus. Schlottheim. Heimberg.
papiraceus. Schlottheim. Heimberg.
æneus. Bourg. T. 40. F. 266.
Nautilites pseudopompilus. Schlottheim. Weimar.
rusticus. Schlottheim. Heimberg, near Gottingen.
Helicites girans. Oryct. Nor. T. III. F. 29.
planorbiformis. Schlottheim. Near Arensberg Thuringia.
Helicites pseudopomarius. Knorr. T. B. vi. *a*. F. 10. Quedlenburg.
Trochilites speciosus. Oryct. Nor. T. vii. F. 20.
nodosus. Schlottheim. Heimberg.
umbilicatus. Schlottheim. Heimberg.
lævis. Schlottheim. Heimberg.
cutus. Schlottheim. Heimberg.
Neritites spiratus. Schlottheim. Arensburg.
gryphus. Schlottheim. Minden.
Turbinites strombiformis. Naturf. 1. S. 1. T. III. F. 3. Palatinate.
communis. Schlottheim.
socialis. Schlottheim. Wissbaden.
approximatus. Schlottheim. Heimberg.
Strombites Jenensis. Know. P. II. 1. T. C. vi. F. 7. Jena.
canaliculatus. Schlottheim. Heimberg.
Buccinites annulatus. Schlottheim. Halberstadt.
gregarius. Schlottheim. Heimberg.
Porcellanites Seelandicus. Schlottheim. Zeeland.
Patellites Vinariensis. Naturf. 5. St. T. III. F. 4. Weimar.
Discites æquilateralis. Schlottheim. Tonna.
Chamites lævis. Bourg. T. 31. F. 120.
auritus. List Anim. Angl. T. 9. F. 51.
striatus. Bourg. T. 25. F. 154.
sulcatus. List Anim. Angl. T. 9. F. 54.

Pectinites subreticulatus. Schlottheim. Teutleben.
Baccardites cordicalis. Oryct. Nor. T. 7. F. 29.
cardissæformis. Schlottheim. Heimberg.
Donacites clausus. Schlottheim. Tonna.
Venulites trigonatus. Schlottheim. Tonna.
Ostracites sulcatus. Blumenb. Spec. Arch. Tel. T. 1. F. 3.
plicatus. Knorr. P. II. 1. T. D. *i*. F. 1—4.
pusillus. Oryct. Nor. T. viii. F. 8.
pyramidans. Oryct. Nor. T. iv. F. 1.
spondyloides. Schlottheim. Tonna.
Terebratulites communis. Knorr. P. II. 1. T. B. iv. F. 2.
giganteus. Blumenb. Abb. T. i. F. 4. Osnabruck.
regularis. Oryct. Nor. T. v. F. 23.
oblongus. Oryct. Nor. T. v. F. 24.
squamiger. Oryct. Nor. T. v. F. 19.
artifex. Knorr. P. II. 1. T. B. iv. F. 7. 8.
sustarcinatus. Oryct. Nor. T. vii. F. 35.
subhistericus. Oryct. Nor. T. vii. F. 37.
parasiticus. Schlottheim. Tonna.
fragilis. Schlottheim. Herda.
bicanaliculatus. Schlottheim. Tonna.
Trigonellites pes anseris. Knorr. P. II. 1. T. B. II. *b*. F. 8. Thuringia.
communis. Knorr. P. II. 1. T. B. II. *b*.
simplex. Schlottheim. Sachsenberg.
Anomites obsoletus. Schlottheim. Lohberg.
Solennites annulatus. Oryct. Nor. T. iv. F. 12. 13. Winkelheid.
Gryphites.
Ratisbonensis. Knorr. P. II. 1. T. D. III. *c*. F. 1. 3.
suillus. Schlottheim. Heimberg.
lævis. Schlottheim. Heimberg.
Musculites gibbosus. Oryct. Nor. T. vii. F. 25.

Musculites comprimatus. Oryct. Nor. T. vii. F. 23.
mytiloides. Oryct. Nor. iv. F. 2.
Pholadites caudatus. Halberstadt.
Mytilites sociatus. Thuringia.
costatus. Lohberg, near Tonna.
Tellinites paganus. Oryct. Nor. T. vii. F. 26. 27.
comprimatus. Sachsenburg.
minutus. Schlottheim. Sachsenburg.
Balanites porosus. Blumenb. Abb. T. i. F. 1. Near Osnabruck.
parasiticus. Lohberg. Tonna.
Trilobites cornigerus. Schlottheim. Near Reval.

Fossil remains of fishes, and, it is said, also of birds, have been found in this formation.

VI. *Chalk Formation.*

This, which is one of the newest of the flœtz limestones, contains many different petrifactions, as will appear from the following enumeration.

Serpulites contortuplicatus. Mont. P. II. p. 25. Petersberg.
peniformis. Schlottheim. Petersberg.
exuviatus. Schlottheim. Island Rugen.
Osteriatites siderolites. Mont. P. 1. p. 150. Petersberg.
Asteriatites spinosus. Schlottheim. Petersberg.
pentagonatus. Schlottheim. Petersberg.
Echinites poundianus. Schlottheim. Kent.
varians. Bourg. T. li. F. 337—339.
anomalus. List. Anim. Angl. T. vii. F. 25.
melitensis. List. Anim. Angl. T. xxvii.
cordiformis. List. Anim. Angl. T. vii. F. 28.
Breynianus. Breyn. Opusel. T. iv. F. 1. 2.
fenestratus. Knorr. T. E. 7. *a.* T. iii.

Echinites canaliculatus. Knorr. P. II. 1. T. E. iv. F. 1. 2.
ursinus. Knorr. P. II. 1. T. E. 1. *a*. F. 4.
hexagonatus. Knorr. P. II. 1. T. E. V. F. 12.
cruciatus. Knor. Suppl. T. ix. *d*. F. 3.
sideralis. Naturf. 9 St. T. iv. F. 7. Petersberg.
echinometrites. Bourg. T. liii. F. 361.

Dentalites minutus. Schlottheim. Island Moen.

Orthoceratites gigsa. Knorr. Suppl. T. xii. F. 1—5.

Telebois annulatus. Montf. P. 1. p. 366. Island of Gothland.

Baculites vertibralis. Montf. P. I. p. 343.

Belemnites reticulatus. Montf. P. I. p. 379. St. Catherine.
pyrgopolon mosæ. Montf. P. I. p. 394.
mucronatus. Breyn. opuscl. Tabula Belemnit. T. 1. *a*. 2. *b*. Faujas.
paxillosus. Montf. P. I. p. 352.
lanceolatus. Breyn. Tab. Bel. F. 7. *a*.

Ammonites mammillatus. Naturf. 1. St. T. II. F. 3.
elipsolites funatus. Montf. P. I. p. 86. St. Catherine.

Nautilites pseudopompilius. Fauj. Petersberg. T. xxi. F. 1.
puppis. Fauj. T. xxv. F. 9. Petersberg.
pulcher. Fauj. T. xx. F. 3. Petersberg.

Srombites globulatus. Knorr. P. II. 1. T. C. vii.

Buccinites Belgicus. Petersberg.

Muricites turrilitis costatus. Montf. P. I. 118. Rouen.

Volutites coniformis. Knorr. P. II. 1. T. C. ii.* F. 6. 7.

Patellites acutus. Fauj. T. xxv. F. 1. Petersberg.
mitratus. Knorr. P. II. ii. T. N. F. 3. Mecklenburg.
melitensis. Knorr. P. II. 1. T. B. 1. *c*. F. 5. 6. Suppl. T. v. *c*. F. 6.
regularis. Fauj. T. T. xxiii. F. 2. Petersberg.
irregularis. Fauj. T. xxiii. F. 3. Petersberg.

Ostracites mysticus. Fauj. T. xxvi. F. 5. Petersberg.
ungulatus. Knorr. P. II. 1. T. D. vii. F. 5. 6. Petersberg.
crista urogalli. Knorr. P. II. 1. T. D. vii. F. 3. 6.
laurifolium. Knorr. P. II. 1. T. D. vii. F. 1. 2.
plicatissimus. Naturf. 9. St. T. iv. F. 6. *a—b*. Kent.
approximatus. Fauj. T. xxiii. F. 5. Petersberg.
crista meleagris. Fauj. T. xxiii. F. 6. Petersberg.
haliotiformis. Fauj. T. xxiii. F. 4. Petersberg.
mactroides. Schlottheim. Champagne.

Terebratulites communis. Fauj. T. xxvi. F. 5. Petersberg.
scaphula. Fauj. T. xxvi. F. 8.
chrysalis. Fauj. T. xxvii. F. 7. & 9.
varians, Fauj. T. xxvii. F. 1.
microscopicus. Fauj. T. xxvi. F. 2.
limbatus. Fauj. T. xxvi. F. 4.
chitoniformis. Fauj. T. xxvi. F. 6.
peltatus. Fauj. T. xxvi. F. 11.
plicatellus. Fauj. T. xxvi. F. 10.
vermicularis. Fauj. T. xxvi. F. 12.
pectiniformis. Fauj. T. xxvii. F. 5.
tenuissimus. Fauj. T. xxvii. F. 7.
concavus. Fauj. T. xxvii. F. 6.
papillatus. Fauj. T. xxvii. F. 8.
gracilis. Schlottheim. Kent.

Pinnites cretaceus. Fauj. T. xxii. F. 1. & 3.

Gryphites politus. Schlottheim. Island Moen.

Tellinites asserculatus. Knorr. Suppl. T. v. c. F. 2. Mecklenburg.

Besides these petrifactions, the following are enumerated by authors as occurring in chalk: spondylites, pec-

tinites, chamites, teeth and bones of fish, also fish much mutilated, tortoises, crabs, alcyonites, madreporites, spongites, and encrinites.*

VII. *Flœtz Trap Rocks.*

These rocks occur in several of the flœtz formations already mentioned, either as subordinate beds, or in mountain masses. In the red sandstone formations they occur in beds, veins, and mountain masses, and appear in single hills, as Salisbury Craig, near Edinburgh, or in ranges of hills, as the Pentlands and Ochils, also near Edinburgh. The only rock of the series which contains petrifactions is the trap-tuff, which includes a few vegetable impressions.

Flœtz trap rocks also occur in the flœtz limestone formation, either in beds or mountain masses; and sometimes we meet with whole ranges of such hills belonging to the flœtz limestone. I do not know that petrifactions have ever been found in the trap of these formations.

The Coal Formation, which forms a great tract of country on both sides of the Frith of Forth, contains beds and veins of flœtz trap rocks. The only trap rock of this series which contains petrifactions is the trap-tuff, and it very rarely presents a few vegetable impressions.

VIII. *Newest Flœtz Trap.*

The newest flœtz trap formation of Werner, which is of a very late date, contains very few petrifactions.

---

* I enumerate in this list the petrifactions discovered by Faujas St. Fond in the Petersberg, near Mæstrich, as it is the opinion of some naturalists that it belongs to the chalk formation.

From the short account now given, it appears, that the flœtz trap-rocks, in whatever situation they occur, contain very few organic remains.*

IX. *Newest Flœtz Formations.*

Over the chalk rests a series of calcarious and siliceous formations, which, in general, abound in petrifactions. They appear to have been deposited from the water of lakes or inland seas, some of which are conjectured to have been alternately filled with fresh and salt water; and hence, in a general view, are of a more local nature than those which have been deposited from the waters of the ocean. The newest members of the series are of so loose a texture, the fossil organic remains they contain so nearly resemble those that now inhabit the earth, and they are so nearly related to the alluvial formations which are daily forming, that it is often extremely difficult, nay even sometimes impossible, to determine whether they belong to the alluvial or newest flœtz formation. There appears to be a gradation or transition from the one into the other. The petrifactions they contain are of zoophytes, shells, fishes, and amphibious animals; and fossil remains of birds and quadrupeds here for the first time appear enclosed in strata. The country around Paris, that of the Isle of Wight, and other districts in the south of England, as particularly described in Note K (B), belong to these newer formations.

X. *Alluvial Formations.*

The mineral substances included under this class are considered to be of newer formation than any of the flœtz rocks; and the following are the most frequent and

* This is the formation considered by many geologists as entirely of volcanic origin.

abundant of these, viz. gravel, sand, clay, loam, marl, calc-tuff, calc-sinter, brown coal, and peat.

Petrifactions frequently occur distributed through these deposites either in a regular or irregular manner, and are sometimes whole, sometimes more or less broken, but angular, or are so much rounded as to show that they have suffered by attrition. Several different alluvial formations may be pointed out, which are characterized by the organic remains they contain. Thus, one formation found in this neighbourhood contains shells of the common oyster, common muscle, patella vulgaris, bucinum undatum and lapillus, nerita littoralis, and turbo littoreus, all of which are still inhabitants of the Frith of Forth. Another contains bones of ruminating animals, as those of the horse, ox, and stag, but differing from those of the living species; and in a third, which contains such marl and many fresh-water shells, there occur the bones of several extinct species of the elephant, rhinoceros, hippopotamus, and also of the Irish elk, which is no longer a native of this country.*

From the preceding short sketch it appears, that the most simple animals are those we first meet with in a mineralized state; that these are succeeded by others more perfect, and which are contained in newer formations; and that the most perfect, as quadrupeds, occur only in the newest formations. But we naturally inquire, have no remains of the human species been hitherto discovered in any of the formations? Judging from the arrangement already mentioned, we would naturally expect to meet with remains of man in the newest of the formations. In the writings of ancient authors, there are

* This latter formation has been lately discovered in Ayrshire.

descriptions of anthropolithi. In the year 1577, Fel. Plater, Professor of Anatomy at Basil, described several fossil bones of the elephant found at Lucerne, as those of a giant at least nineteen feet high. The Lucernese were so perfectly satisfied with this discovery, that they caused a painting to be made of the giant as he must have appeared when alive, assumed two such giants as the supporters of the city arms, and had the painting hung in their public hall. The Landvoigt Engel, not satisfied with this account of these remains, maintained that our planet, before the creation of the present race of men, was inhabited by the fallen angels, and that these bones were parts of the skeletons of some of those miserable beings. Scheuchzer published an engraving and description of a fossil human skeleton, which proved to be a gigantic species of salamander or proteus. Spallanzani describes a hill of fossil human bones in the island of Cerigo; but this also is an error, as has been satisfactorily shown by Blumenbach. Lately, however, a fossil human skeleton has been imported into this country from Gaudaloupe by Sir Alexander Cochrane. It is imbedded in a block of calcarious stone, composed of particles of limestone and coral, and which, like the aggregations of shells found on the limestone coasts in some parts of this country, has acquired a great degree of hardness. It is therefore an instance of a fossil human petrifaction in an alluvial formation. The engraving here given is copied from the Philosophical Transactions of the Royal Society of London; and the following description of the fossil remains it exhibits is that of Mr. Konig, which has been drawn up with great care.

"The situation of the skeleton in the block was so superficial, that its presence in the rock on the coast had

probably been indicated by the projection of some of the more elevated parts of the left fore-arm.

"The operation of laying the bones open to view, and of reducing the superfluous length of the block at its extremities, being performed with all the care which its excessive hardness and the relative softness of the bones required, the skeleton exhibited itself in the manner represented in the annexed drawing (Pl. I.), with which my friend Mr. Alexander has been so good as to illustrate this description.

"The skull is wanting; a circumstance which is the more to be regretted, as this characteristic part might possibly have thrown some light on the subject under consideration, or would, at least, have settled the question, whether the skeleton is that of a Carib, who used to give the frontal bone of the head a particular shape by compression, which had the effect of depressing the upper and protruding the lower edge of the orbits, so as to make the direction of their opening nearly upwards, or horizontal, instead of vertical.*

"The vertebræ of the neck were lost with the head. The bones of the thorax bear all the marks of considerable concussion, and are completely dislocated. The seven true ribs of the left side, though their heads are not in connexion with the vertebræ, are complete; but only three of the false ribs are observable. On the right side only fragments of these bones are seen; but the upper part of the seven true ribs of this side are found on the left, and might at first sight be taken for the termination of the left ribs; as may be seen in the drawing. The

* See the excellent figures in Blumenbach's Decades.

right ribs must therefore have been violently broken and carried over to the left side, where, if this mode of viewing the subject be correct, the sternum must likewise lie concealed below the termination of the ribs. The small bone dependent above the upper ribs of the left side, appears to be the right clavicle. The right os humeri is lost; of the left nothing remains except the condyles in connexion with the fore-arm, which is in the state of pronation; the radius of this side exists nearly in its full length, while of the ulna the lower part only remains, which is considerably pushed upwards. Of the two bones of the right fore-arm, the inferior terminations are seen. Both the rows of the bones of the wrists are lost, but the whole metacarpus of the left hand is displayed, together with part of the bones of the fingers: the first joint of the fore-finger rests on the upper ridge of the os pubis; the two others, detached from their metacarpal bones, are propelled downwards, and situated at the inner side of the femur, and below the foramen magnum ischii of this side. Vestiges of three of the fingers of the right hand are likewise visible, considerably below the lower portion of the fore-arm, and close to the upper extremity of the femur. The vertebræ may be traced along the whole length of the column, but are in no part of it well defined. Of the os sacrum, the superior portion only is distinct; it is disunited from the last vertebra and the ilium, and driven upwards. The left os ilium is nearly complete, but shattered, and one of the fragments depressed below the level of the rest; the ossa pubis, though well defined, are gradually lost in the mass of the stone. On the right side, the os innominatum is completely shattered, and the fragments are sunk; but towards the acetabulum, part of its internal cellular structure is discernible.

The thigh bones and the bones of the leg of the right side are in good preservation, but being considerably turned outwards, the fibula lies buried in the stone, and is not seen. The lower part of the femur of this side is indicated only by a bony outline, and appears to have been distended by the compact limestone that fills the cavities both of the bones of the leg and thigh, and to the expansion of which these bones probably owe their present shattered condition. The lower end of the left thigh bone appears to have been broken and lost in the operation of detaching the block; the two bones of the leg, however, on this side, are nearly complete; the tibia was split almost the whole of its length a little below the external edge, and the fissure being filled up with limestone, now presents itself as a dark-coloured straight line. The portion of the stone which contained part of the bones of tarsus and metatarsus, was unfortunately broken; but the separate fragments are preserved.

"The whole of the bones, when first laid bare, had a mouldering appearance, and the hard surrounding stone could not be detached without frequently injuring their surface; but after an exposure for some days to the air, they acquired a considerable degree of hardness. Sir H. Davy, who subjected a small portion of them to chemical analysis, found that they contained part of their animal matter, and all their phosphate of lime."

Note M. (a) § 28. 109.

Cuvier's Geological Discoveries.

As the Essay on the Theory of the Earth does not contain a full account of the numerous geological discoveries and observations of Professor Cuvier, we shall lay before our readers a condensed view of the most import-

ant of these, drawn up chiefly from his great work on the Fossil Remains of Quadrupeds.

Mineralogy of Paris.

In order to enable the reader to understand the various details in regard to the fossil remains discovered by Cuvier, we shall premise a short description of the mineralogy of Paris, as many of them were dug up in that neighbourhood. Chalk, which is the fundamental rock of the district, is covered with *plastic clay*, and what is termed *coarse marine limestone*. The limestone abounds in marine petrifactions, and is associated with a kind of siliceous limestone, which contains the well-known mineral in the arts, used as a millstone, and named *buhrstone.* Over this limestone rests a remarkable formation of *gypsum.* It alternates with beds of marl, containing menilite, and beds of clay, with imbedded lenticular crystals of gypsum. The gypsum contains remains of extinct quadrupeds, birds, amphibious animals, fishes, and shells, all of which are said to be land or fresh water species; hence it is denominated *a fresh water formation.* Above this gypsum lie beds of *marl* and *sandstone* that contain marine shells, thus affording another marine formation. These rocks are covered with beds of *millstone,* limestone and flint, both of which contain petrifactions of fresh water shells; hence this association is named the *second fresh water formation.* The uppermost formation is of an *alluvial* nature. It is composed of variously coloured sand, marl, clay, or a mixture of these substances impregnated with carbon, which gives the mixture a brown or black colour. It contains rolled stones of different kinds, but is most particularly characterized by containing the remains of large organic bodies. It is in this formation that we find great trunks of trees, bones of elephants, also of oxen, rein-deer, and other mammalia. From the intermixture

of fresh and salt water organic productions in these formations, we may suppose that both these fluids must have contributed each their part in their formation. According to Cuvier, and Brongniart, who assisted him in examining these formations we have just enumerated, there appears to have been an alternate flux and reflux of salt and fresh water over the country around Paris, and from which these rocks were deposited. This opinion, however, is liable to numerous objections.—

Fossil Organic Remains described by Cuvier, *arranged in a Systematic Order.*

CLASS.—MAMMALIA.

ORDER.—DIGITATA.

Family. Glires.

Cavia.

In the quarries of slaty limestone of Aeningen there occur remains of a species of this genus which Cuvier conjectures to belong to the cavia porcellus or Guinea pig, or more likely to an unknown species either of this tribe or of that entitled *arvicola.*

Mus.

In the slaty limestone rocks at Walsch, in the circle of Saatz in Bohemia, there are fossil remains of a species of this tribe very nearly allied to the mus terrestris.

Family. Feræ.

Ursus. Bear.

1. *U. Spelæus.*—The size of a horse, and different from any of the present existing species.

2. *U. Arctoideus.*—Is a smaller species, and appears also to be extinct. Both species are fossil, and remains of them are found in great abundance in limestone caves in Germany and Hungary. These caves vary much in magnitude and form, and are more or less deeply incrusted with calcarious sinter, which assumes a great variety of singular and often beautiful forms. The bones occur nearly in the same state in all these caves: detached, broken, but never rolled, and consequently have not been brought from a distance by the agency of water: they are somewhat lighter, and less compact than recent bones, but slightly decomposed contain much gelatine, and are never mineralized. They are generally enveloped in an indurated earth, which contains animal matter; sometimes in a kind of alabaster or calcarious sinter, and by means of this mineral are sometimes attached to the walls of caves. These bones are the same in all the caves hitherto examined; and it is worthy of remark, that they occur in an extent of upwards of 200 leagues.

Esper, who examined and described the caves of Gaylenreuth, on the frontiers of Bayreuth, informs us, that after passing through a succession of caves, he at length came to a narrow passage, which led into a small cave, eight feet high and wide, which is the passage into a grotto twenty-eight feet high, and about forty-three feet long and wide. Here the prodigious quantity of animal earth, the vast number of teeth, jaws, and other bones, and the heavy grouping of the stalactites, produced so dismal an

31

appearance, as to lead Esper to speak of it as a fit temple for a god of the dead. Here hundreds of cart-loads of bony remains might be removed, bags might be filled with fossil teeth, and animal earth was found to reach to the utmost depth to which they dug. A piece of stalactite being here broken down, was found to contain pieces of bones within it.

Cuvier estimates, that rather more than three-fourths of these bones belong to species of bears now extinct; one-half, or two-thirds, of the remaining fourth belong to a species of hyæna, which occurs in a fossil state in other situations. A very small number of these remains belong to a species of the genus lion or tiger; and another to animals of the dog or wolf kinds; and lastly, the smallest portion belongs to different species of smaller carnivorous animals, as the fox and pole-cat. We do not find in these caves any remains of the elephant, rhinoceros, horse, buffalo, or tapir, which occur so commonly in alluvial soil; and the palæotheria of the flœtz strata, the ruminating animals, and the gnawers, of the rock of Gibraltar, Dalmatia, and Cette, are never met with. Nor do we ever find the bears and tigers of these caves in alluvial soil, or in the fissures of rocks. The only one of the species found in these caves, and which is found elsewhere in other formations, is the hyæna, which occurs also in alluvial strata. It is quite evident that these bones could not have been introduced into these caves by the action of water, because the smallest processes, or inequalities, on their surface are preserved. Cuvier is therefore inclined to conjecture, that the animals to which they belonged must have lived and died peaceably on the spot where we now find them. This opinion is rendered highly probable from the nature of the earthy matter in which they are enveloped, and which, according to

Laugier, contains an intermixture of animal matter with phosphate of lime, and probably also phosphate of iron.

Canis. Dog.

Of this genus several species are described as occurring in the caves already mentioned; one species very closely resembles the *Cape hyæna,* and is about the size of a small brown bear; another species is allied to the *dog or wolf;* and a third species is almost identical with the *common fox.** A fossil species also resembling the common fox has been found in the gypsum quarries near Paris; and in the same formation there are fossil remains of a genus intermediate between *canis* and *viverra.* In the alluvial deposites there are remains of the *hyæna.*

Felis. Cat.

One species of this tribe occurs in the limestone caves, and appears to be nearly allied to the *iaguar;* another species, nearly allied to the *tiger,* is found in alluvial soil along with fossil remains of the elephant, rhinoceros, hyæna, and mastodon.

Viverra. Weasel.

Two species of this genus occur in the limestone caves; the one is allied to the common *pole cat,* and the other to the *zorille,* a pole cat belonging to the Cape of Good Hope. Another species allied to the *ichneumon,* but double its size, occurs in the gypsum quarries around Paris.

---

* Blumenbach has lately described the remains of a fossil hyæna, nearly resembling the *canis crocuta,* which was found in marl along with remains of the lion and the elephant, between Osterode and Herzberg in Hanover.

Family. Bruta.

Bradypus. Sloth.

There are but two living species of the sloth tribe, the ai, or bradypus tridactylus; and the unau, or bradypus didactylus. Cuvier describes two fossil species which are nearly allied not only to these species, but also to the myrmecophaga or ant-eater. The following are the two fossil species:—

1. *Megalonix.* It is the size of an ox, and its bones were first discovered in limestone caves in Virginia in the year 1796. 2. *Megatherium.* This species is the size of the rhinoceros, and its fossil remains have hitherto been found only in South America. The first, and most complete skeleton, was sent from Buenos Ayres by the Marquis Loretto, in the year 1789. It was found in digging an alluvial soil, on the banks of the river Luxan, a league south-east of the village of that name, about three leagues W. S. W. of Buenos Ayres. *Plate* **3d** gives a faithful representation of this remarkable skeleton, which is now preserved in the Royal Cabinet of Madrid. A second skeleton of the same animal was sent to Madrid from Lima, in the year 1795; and a third was found in Paraguay. Thus it appears, that the remains of this animal exists in the most distant parts of South America. It is very closely allied to the megalonix, and differs from it principally in size, being much larger. Cuvier is of opinion, that the two species, the megalonix and megatherium, may be placed together, as members of the same genus, and should be placed between the sloths and ant-eaters, but nearer to the former than to the latter. It is worthy of remark, that the remains of these animals have not been hitherto found in any other

quarter of the globe besides America, the only country which affords sloths and ant-eaters.

ORDER.—MARSUPIALIA.

Didelphis.

One species of this extraordinary tribe of animals has been found in a fossil state in the gypsum quarries near Paris. It does not belong to any of the present existing species, and is therefore considered as extinct. Cuvier remarks, that as all the species of this genus are natives of America, it is evident that the hypothesis advanced by some naturalists, of all the fossil organic remains of quadrupeds having been flooded from Asia to northern countries, is erroneous.

ORDER.—SOLIDUNGULA.

Equus. Horse.

Equus. Caballus?

Fossil remains of a species of horse are found in alluvial soil associated with those of the elephant, rhinoceros, hyæna, mastodon and *tiger?* Cuvier confesses that he is not in possession of any means of ascertaining the species of horse to which they belong; it is conjectured that they may belong to the equus caballus, the common horse.

ORDER.—BISULCA.

Cervus. Deer.

1. *Fossil Elk of Ireland.*—This is the most celebrated

of all the fossil ruminating animals. It is most certainly a different species from any of those that at present live on the earth's surface, and may therefore be considered as extinct. It was first found in Ireland, where it generally occurs in shell marl and in peat bogs. It has also been found in superficial alluvial soil in England, Germany, and France.

In Plate II. we have given a drawing of the head and horns of this animal. It was dug out of a marl-pit at Dardistoun, near Drogheda, in Ireland. Dr. Molyneux, in the Philosophical Transactions, informs us that its dimensions were as follows:—

		Feet.	Inches.
From the extreme tip of each horn, -	a. b.	10	10
From the tip of the right horn to its root, - - - - - -	c. d.	5	2
From the tip of one of the inner branches to the tip of the opposite branch, -	e. f.	3	$7\frac{1}{2}$
The length of one of the palms, within the branches, - - - -	g. h.	2	6
The breadth of the palm, within the branches, - - - - - -	i. k.	1	$10\frac{1}{2}$
The length of the right brow antler, -	d. l.	1	2
The beam of each horn, at some distance from the head, in diameter, - -	m.	0	$2\frac{1}{10}$
in circumference, -		0	8
The beam of each horn, at its root, in circumference, - - - - -	d.	0	11
The length of the head, from the back of the skull to the extremity ofthe upper jaw, - - - - -	n. o.	2	0
Breadth of the skull, - - -	p. q.	1	0

2. *Fossil Deer of Scania.*—This species of fossil deer was found in a peat-moss in Scania. It appears from the description of the horns, to be an extinct, or at least an unknown species.

3. *Fossil Deer of Somme.*—This species is allied to the fallow-deer. The horns, the only parts hitherto dicovered, show that this animal, although nearly allied to the fallow-deer, must have been much larger. The horns occur in loose sand, and have been found in the valley of Somme in France, and also in Germany.

4. *Fossil Deer of Etampes.*—This species appears to be allied to the rein-deer, but much smaller, not exceeding the roe in size. The bones were found in abundance near Etampes in France, imbedded in sand.

5. *Fossil Roe of Orleans.*—This species was found in the vicinity of Orleans in France. It occurs in limestone, along with bones of the palæotherium. It is the only instance known of the remains of a living species having been found along with those of extinct species. But Cuvier inquires, May not the bones belong to a species of roe, of which the distinctive characters lie in parts hitherto undiscovered?

6. *Fossil Roe of Somme.*—This species, the remains of which were found in the peat of Somme, appears to be very nearly allied to the roe.

7. *Fossil Red-Deer or Stag.*—This species resembles the red-deer or stag. Its horns are found abundantly in peat-bogs, or sand-pits, in England, France, Germany, and Italy.

Bos. Ox.

1. *Aurochs.*—This species Cuvier considers as distinct from the common ox, and differs from the present existing varieties in being larger. Skulls and horns of this species have been found in alluvial soil in England, Scotland, France, Germany, and America.

2. *Common Ox.*—The fossil skulls of this species differ from those of the present existing races, in being larger, and the direction of the horns being different. They occur in alluvial soil in many different parts of Europe, and are considered by Cuvier as belonging to the original race of the present domestic ox.

3. *Large Buffalo of Siberia.*—The fossil skull of this animal is of great size, and appears to belong to a species different from any of those at present known. It is not the common buffalo, nor can it be identified with the large buffalo of India, named *arnee*. Cuvier conjectures that it must have lived at the same time with the fossil elephant, and rhinoceros, in the frozen regions of Siberia.

4. *Fossil Ox, resembling the Musk Ox of America.*—The fossil remains of this species more nearly resemble the American musk ox than any other species, and have hitherto been found only in Siberia.

It would appear, from the facts just stated, that these fossil remains, both of deer and oxen, may be distinguished into two classes, the unknown and the known ruminants. In the first class Cuvier places the Irish elk, the small deer of Etampes, the stag of Scania, and the great buffalo of Siberia; in the second class he places the

common stag, the common roe-buck, the aurochs, the ox which seems to have been the original of the domestic ox, the buffalo with approximated horns, which appears to be analogous to the musk ox of Canada; and there remains a dubious species, the great deer of Somme, which much resembles the common fallow-deer.

From what has been ascertained in regard to the strata in which these remains have been found, it would appear that the known species are contained in newer beds than the unknown. Further, that the fossil remains of the known species are those of animals of the climate where they are now found: thus the stag, ox, aurochs, roe-deer, musk ox of Canada, now dwell, and have always dwelt, in cold countries; whereas the species which are regarded as unknown, appear to be analogous to those of warm countries: thus the great buffalo of Siberia can only be compared with the buffalo of India, the arnee. M. Cuvier concludes, that the facts hitherto collected seem to announce, at least as plainly as two imperfect documents can, that the two sorts of fossil ruminants belong to two orders of alluvial deposites and consequently to two different geological epochas; that the one have been, and are now, daily becoming enveloped in alluvial matter; whereas the others have been the victims of the same revolution which destroyed the other species of the alluvial strata; such as mammoths, mastodons, and all the multungula, the genera of which now exist only in the torrid zone.

ORDER.—MULTUNGULA.

Rhinoceros.

Three species of this genus are at present known to naturalists, as inhabitants of different parts of the world. These are the two-horned rhinoceros of Africa, the one-horned rhinoceros of Asia, and the rhinoceros of the island of Sumatra. Only one fossil species has hitherto been discovered, which differs from the three living species, not only in structure, but in geographical distribution. It was first noticed in the time of Grew, and the bones he mentions were dug out of alluvial soil near Canterbury. Since that period similar remains have been found in many places of Germany, France, and Italy. In Siberia, not only single bones and skulls, but the whole animal, with the flesh and skin, have been discovered.

Hippopotamus.

Only one species of this genus is at present known to live on the surface of the earth. It is an inhabitant of Africa, and, according to Marsden, also of Asia, for he mentions it as one of the animals of the island of Sumatra. M. Cuvier is inclined to call in question the accuracy of this statement of Marsden's, and to conjecture that he may have confounded the succotyro of Newhoff with the hippopotamus. Mr. Marsden, in the new edition of his excellent description of Sumatra, still enumerates the hippopotamus amongst the Sumatrian animals, but appears to have misunderstood Cuvier, when he says that he accuses him of confounding the hippopotamus

with the *dugong*.* Two fossil species have been ascertained by Cuvier. The one, which is the largest, is so very nearly allied to the species at present living on the surface of the earth, that it is difficult to determine whether or not it is not the same. Its fossil remains have been found in alluvial soil in France and Italy. The second fossil species, and the smallest, the animal not being larger than a hog, is well characterized, and is entirely different from any of the existing species of quadrupeds.

Tapir.

The tapir is an animal peculiar to the new world, and has hitherto been found only in South America. Yet two fossil species of this genus have been discovered in

---

* "Hippopotamus, *Küda-ayer.* The existence of this quadruped in the island of Sumatra having been questioned by M. Cuvier, and not having myself actually seen it, I think it necessary to state, that the immediate authority upon which I included it in the list of animals found there, was a drawing made by *M. Whalfeldt*, an officer employed in a survey of the coast, who had met with it at the mouth of one of the southern rivers, and transmitted the sketch along with his report to the government, of which I was then secretary. Of its general resemblance to that well-known animal there could be no doubt. M. Cuvier suspects that I may have mistaken it for the animal called by naturalists the *dugong*, and vulgarly the sea-cow, which will be hereafter mentioned; and it would indeed be a grievous error, to mistake for a beast with four legs, a fish with two pectoral fins, serving the purposes of feet; but independently of the authority I have stated, the *küda-ayer*, or river horse, is familiarly known to the natives, as is also the duyong (from which Malayan word the dugong of naturalists has been corrupted); and I have only to add, that in a register given by the Philosophical Society of Batavia, in the first volume of their Transactions, for 1799, appears the article, '*conda aijeer*, rivier paard, hippopotamus,' amongst the animals of Java."—MARSDEN'S *History of Sumatra*, 3d edit. p. 116, 117.

Europe. The one is named the small, the other the gigantic tapir, and both have been found in different parts of France, Germany, and Italy.

Elephant, or Mammoth.

Of this genus two species are at present known as inhabitants of the earth. The one, which is confined to Africa, is named the African elephant; the other, which is a native of Asia, is named the Asiatic elephant. Only one fossil species has hitherto been discovered. It is the *mammoth* of the Russians. It differs from both the existing species, but agrees more nearly with the Asiatic than the African species.* Its bones have been found in many different parts of this island; as in the alluvial soil around London, in the county of Northampton, at Gloucester, at Trenton, near Stafford, near Harwich, at Norwich, in the island of Sheppey, in the river Medway, in Salisbury Plain, and in Flintshire in Wales; and similar remains have been dug up in the north of Ireland. Bones of this animal have been dug up in Sweden, and Cuvier conjectures that the bones of supposed giants, mentioned by the celebrated Bishop Pontoppidan as having been found in Norway, are remains of the fossil elephant. Torfæus mentions a head and tooth of this animal dug up in the island of Iceland. In Russia in Europe, Poland, Germany, France, Holland, and Hungary, teeth and bones of this species of elephant have been found in abundance. Humboldt found teeth of this animal in North and South America. But it is in Asiatic Russia that they occur in greatest abundance. Pallas says, that from the Don or the Tanais to Tchutskoinoss, there is scarcely a river the

---

* These three species are well distinguished by the appearance of the surface of the grinding teeth, as is shown in *plate second.*

bank of which does not afford remains of the mammoth; and these are frequently imbedded in, or covered with, alluvial soil, containing marine productions. The bones are generally dispersed, seldom occurring in complete skeletons, and still more rarely do we find the fleshy part of the animal reserved. One of the most interesting instances on record of the preservation of the carcass of this animal, is given by M. Cuvier in the following relation.*

"In the year 1799, a Tungusian fisherman observed a strange shapeless mass projecting from an ice-bank, near the mouth of a river in the north of Siberia, the nature of which he did not understand, and which was so high in the bank as to be beyond his reach. He next year observed the same object, which was then rather more disengaged from among the ice, but was still unable to conceive what it was. Towards the end of the following summer, 1801, he could distinctly see that it was the frozen carcass of an enormous animal, the entire flank of which and one of its tusks had become disengaged from the ice. In consequence of the ice beginning to melt earlier and to a greater degree than usual in 1803, the fifth year of this discovery, the enormous carcass became entirely disengaged, and fell down from the ice-crag on a sand-bank forming part of the coast of the Arctic ocean. In the month of March of that year, the Tungusian carried away the two tusks, which he sold for the value of fifty rubles; and at this time a drawing was made of the animal, of which I possess a copy.

* This singular discovery is given by Professor Cuvier, as taken from a Report in the Supplement to the *Journal du Nord*, No. xxx. by M. Adams, adjunct member of the Academy of St. Petersburgh.

"Two years afterwards, or in 1806, Mr. Adams went to examine this animal, which still remained on the sand-bank where it had fallen from the ice, but its body was then greatly mutilated. The *Jukuts* of the neighbourhood had taken away considerable quantities of its flesh to feed their dogs; and the wild animals, particularly the white bears, had also feasted on the carcass; yet the skeleton remained quite entire, except that one of the fore-legs was gone. The entire spine, the pelvis, one shoulder-blade, and three legs, were still held together by their ligaments and by some remains of the skin; and the other shoulder-blade was found at a short distance. The head remained, covered by the dried skin, and the pupil of the eyes was still distinguishable. The brain also remained within the skull, but a good deal shrunk and dried up; and one of the ears was in excellent preservation, still retaining a tuft of strong bristly hair. The upper lip was a good deal eaten away, and the under lip was entirely gone, so that the teeth were distinctly seen. The animal was a male, and had a long mane on its neck.

"The skin was extremely thick and heavy, and as much of it remained as required the exertions of ten men to carry away, which they did with considerable difficulty. More than thirty pounds weight of the hair and bristles of this animal were gathered from the wet sand-bank, having been trampled into the mud by the white bears while devouring the carcass. Some of the hair was presented to our Museum of Natural History by M. Targe, censor in the Lyceum of Charlemagne. It consists of three distinct kinds. One of these is stiff black bristles, a foot or more in length; another is thinner bristles, or coarse flexible hair, of a reddish brown colour; and the third is a coarse reddish-brown wool,

which grew among the roots of the long hair. These afford an undeniable proof that this animal had belonged to a race of elephants inhabiting a cold region, with which we are now unacquainted, and by no means fitted to dwell in the torrid zone. It is also evident that this enormous animal must have been frozen up by the ice at the moment of its death.

"Mr. Adams, who bestowed the utmost care in collecting all the parts of the skeleton of this animal, proposes to publish an exact account of its osteology, which must be an exceedingly valuable present to the philosophical world. In the mean time, from the drawing I have now before me, I have every reason to believe that the sockets of the teeth of this northern elephant have the same proportional lengths with those of other fossil elephants, of which the entire skulls have been found in other places."*

Sus. Hog.

Only single bones and teeth of this tribe have been hitherto met with, and these appear to belong to the sus scrofa, or common hog. They are found in peat mosses, or in very new alluvial deposites.

Mastodon.

This is entirely a fossil genus, no living species having hitherto been discovered in any part of the world. It is more nearly allied to the elephant than to any other ani-

* It is worthy of remark, that although fossil bones of the elephant were described as such in the middle of the 16th century by Aldrovandus, it was not until two centuries afterwards that this opinion was credited. In the intermediate time they were described as lusus naturæ, bones of giants, *skeletons of fallen angels*, remains of marine animals, or of colossal baboons.

mal of the present creation; it appears to have been a herbivorous animal; and the largest species, the *great mastodon* of Cuvier, was equal in size to the elephant. Five species are described by Cuvier.

1. *Great Mastodon.*—This species has been hitherto found in greatest abundance in North America, near the river Ohio, and remains of it have been also dug up in Siberia. It has been frequently confounded with the mammoth or fossil elephant, and in North America it is named mammoth. In *plate* 2*d* we have given an engraving of one of the grinding teeth of this animal.

2. *Mastodon with narrow Grinders.*—The fossil remains of this species have been dug up at Simorre and many other places in Europe, and also in America.

3. *Little Mastodon with small Grinders.*—This species is much less than the preceding, and was found in Saxony and Montabusard.

4. *Mastodon of the Cordilleras.*—This species was discovered in South America by Humboldt. Its grinders are square, and it appears to have equalled in size the great mastodon.

5. *Humboldien Mastodon.*—This, which is the smallest species of the genus, was found in America by Humboldt.

All the fossil species of quadrupeds we have just enumerated have been found in the alluvial soil which covers the bottoms of valleys, or is spread over the surface of plains. All of them are stangers to the climate where these bones now rest. The five species of mastodons alone may be considered as forming a distinct and hitherto unknown genus, nearly allied to that of the elephant.

All the others belong to genera still existing in the torrid zone. Three of these genera, viz. the rhinoceros, hippopotamus, and elephant, occur only in the old world; the fourth, the tapir, exists only in the new world. But the fossil species have not the same geographical distribution: It is in the old world that we dig up the bones of the tapir, and some remains of the elephant have been discovered in the new world. The fossil species included under the known genera differ sensibly from the present species, and are certainly not mere varieties. Of all the eleven fossil species, the large hippopotamus is the only one which we cannot say with certainty does not belong to the present living species of that genus. The small hippopotamus and gigantic tapir are unquestionably new species; there is scarcely a doubt of the fossil rhinoceros being a distinct species; and although the fossil elephant and the little tapir are not so well marked as new species, yet, as Cuvier remarks, there are reasons sufficient to convince the experienced anatomist of their being different from any of the present existing species. These different fossil bones are found almost everywhere in beds of nearly the same kind; they are often promiscuously mixed with bones of animals resembling the species of the present time. These beds are generally alluvial, either sandy or marly, and always near the earth's surface. It is therefore probable that these bones have been enveloped by the last, or one of the last, catastrophes to which our earth has been subjected. In many places they are accompanied with accumulations of marine animal remains, and in other places the sand and marl which cover them contain only fresh water shells. We have no authentic account of their having been found covered with flœtz, or other solid strata containing marine animals, and therefore cannot affirm that they were for a long time covered with a tranquil sea.

The catastrophe, then, which has covered them, appears to have been a transient marine inundation. This inundation does not appear to have reached to the high mountains, because the formation in which these remains are found does not occur there, and these bones are not found in the high valleys, if we except a few in the warmer parts of America. The bones are neither rolled nor in skeletons, but dispersed, and in part broken or fractured. They have not therefore been brought there from a distance by an inundation, but have been found by it in the places where it has covered them, as might be expected, if the animals to which they belonged had dwelt in these places, and had there successively died. Hence it appears, that before this catastrophe these animals lived in the countries where we now find their bones: It is this inundation which has destroyed them; and as we do not find them elsewhere, the species must have been annihilated. It would thus appear, that the northern parts of the globe formerly nourished species belonging to the elephant, hippopotamus, rhinoceros, tapir, and mastodon tribes; and all of these, with exception of the mastodon, which is entirely a fossil genus, have species living, but only in the torrid zone. Nevertheless there is nothing to countenance the belief, that the species of the torrid zone have descended from the ancient animals of the north, which have been gradually or suddenly transported toward the equator. They are not the same; and we may see, by the examination of the most ancient mummies, as those of the ibis, that no established fact authorizes the belief of changes so great as those which must be assumed for such a transformation, especially in wild animals. Nor are there any decisive proofs of the temperature of northern climates having changed since this epoch. The fossil species do not differ less from the living, than certain northern animals differ from their co-genera of the south;—

the *isatis* of Siberia, for example, *(canis lagopus)* from the *chacal* of India and of Africa *(canis aureus)*. They therefore ought to have belonged to much colder climates.

*Palæotherium.**

This is a new and entirely fossil genus, which was found by Cuvier in the rocks around Paris. The following are the characters of the genus and the species:

Dentes 44. *Primores utrinque* 6.
Laniarii 4, *acuminati paulo longiores, tecti.*
Molares 28, *utrinque* 7. *Superiores quadrati; inferiores bilunati.*
Nasus productior, flexilis.
Palmæ et plantæ tradactylæ.

1. P. Magnum.	*Statura Equi.*
2. P. Medium.	*Statura Suis; pedibus strictis, subelongatis.*
3. P. Crassum.	*Statura Suis; pedibus latis, brevioribus.*
4. P. Curtum.	*Pedibus ecurtatis patulis.*
5. P. Minus.	*Statura Ovis; pedibus strictis, digitis lateralibus minoribus.*

Besides these five species found in the gypsum quarries around Paris, remains of others have been discovered in other parts of France, either imbedded in the *fresh water limestone*, or in alluvial soil. Cuvier enumerates and describes the following species:

6. P. Giganteum.	*Statura Rhinocerotis.*
7. P. Tapiroides.	*Statura Bovis; molarium inferiorum colliculis fere rectis, transversis.*

* Palæotherium signifies ancient large animal, or beast.

8. P. Buxovillanum. *Statura Suis; molaribus inferioribus extus sub gibbosis.*

9. P. Aurelianensi. *Statura Suis; molarium inferiorum angulo intermedio bicorni.*

10. P. Occitanicum. *Statura Ovis; molarium inferiorum angulo intermedio bicorni.*

*Anoplotherium.**

This also is another fossil genus first discovered by Cuvier. The following are its characters:

Dentes 44, *serie continua.*
Primores utrinque 6.
Laniarii primoribus similes, ceteris non longiores.
Molares 28, *utrinque* 7. *Anteriores compressi. Posteriores superiores quadrati. Inferiores bilunati.*
Palmæ et plantæ didactylæ, ossibus metacarpi et metatarsi discretis; digitis accessoriis in quibusdam.

1. A. Commune. *Digito accessorio duplo breviori, in palmis tantum; cauda corporis longitudine crassissima.*
Magnitudo Asini aut Equi minor is.
Habitus elongatus et depressus Lutræ.
Verisimiliter natatorius.

2. A. Secundarium. *Similis præcedenti, sed statura Suis. E tibia et molaribus aliquot cognitum.*

3. A. Medium. *Pedibus elongatis, digitis, accessoriis nullis.*
Magnitudo et habitus elegans Gazellæ.

4. A. Minus. *Dignito accessorio utrinque, in palmis et plantis, intermedios fere æquante.*
Magnitude et habitus Leporis.

* Anoplotherium signifies beast without weapons; thus referring to its distinguishing character, its want of canine teeth.

5. A. Minimum. *Statura paviæ Cobayæ, e maxilla tantum cognitum.*
Habitatio omnium, olim, in regione ubi nunc Lutetia Parisiorum.

ORDER.—PALMATA.

Family. Glires.

Castor. Beaver.

Cuvier describes two species of beaver found in alluvial strata. The one, which is nearly allied to the *castor fiber*, or *common beaver*, is found in France; the other, found on the shores of the sea of Azof by M. Fischer, differs from the former, and is named *castor trogontherium*.

Family. Feræ.

Phoca. Seal.

The remains of a species of seal nearly three times the size of the common seal, or phoca vitulina, have been found in the coarse marine limestone of the department of the Maine and Loire. Another species of this genus, but somewhat less than the common, is also described by Cuvier, as occurring in the same limestone.

Family. Bruta.

Lamantin.

Two species of this remarkable genus have been found imbedded in the coarse marine limestone of the department of the Maine and Loire.

CLASS.—AVES.

Sturnus. Starling.

Fossil remains of species of this genus occur in the formations around Paris.

Coturnix. Quail.

Bones of this tribe of birds have been found in the strata near Paris.

Sterna. Tern.

Bones of terns are occasionally found along with those of the quail in the Parisian strata.

Grallæ. Wadders.

Bones of birds resembling those of the order grallæ have been found near Paris enclosed in the solid rocks.

Pelicanus. Pelican.

Bones nearly resembling those of the pelican tribe occur in the Paris formations.

CLASS.—AMPHIBIA.

ORDER.—REPTILES.

Testudo. Tortoise.

Fossil remains of this genus are met with in different parts of Europe. Thus, fossil tortoises, of unknown species, are found imbedded in coarse marine limestone at

the village of Melsbroeck, in the environs of Brussels. Fossil remains of unknown species of tortoises are also met with in the coarse chalk or limestone of the hill of Saint Peter, near Maestricht. They are irregularly distributed throughout the masses of the rock, along with different marine productions, and bones of the gigantic monitor. All of them are remains of sea-tortoises, named chelonii by French zoologists; but of species different from any of those at present known.

Remains of a marine, but unknown species of tortoise were found in the limestone slate of Glaris; and remains of unknown species have also been dug out of the rocks of a formation analogous to that around Paris, situated in the vicinity of Aix. And fossil fresh-water species have been found in the gypsum quarries near Paris.

Crocodilus. Crocodile.

Two extinct species of fossil crocodiles, nearly allied to the gavial (Lac. gangeticus) or gangetic crocodile, occur in a pyritical bluish-gray compact limestone, at the bottom of the cliffs of Honfleur and Havre; and one of these species at least is found in other parts of France, as at Alençon and elsewhere.* It would also appear that the skeleton of a crocodile, discovered at the bottom of a cliff of pyritical slate, about half a mile from Whitby, by Captain William Chapman, probably belongs to one of these species. And it may further be remarked, that the fragments of heads of crocodiles found in the Vicentine, may be referred to the same species. 2. That the fossil heads, found at Altorf, are different from those of

* Cuvier describes bones of a crocodile found in the slaty limestone of Altorf, which had been considered as remains of the human species.

the gavial, and have a longer snout than that of the animal of Honfleur, and may therefore belong to the other fossil species found in France. 3. That the remains of an unknown species of fossil crocodile was found near Newark, in Nottinghamshire, by Dr. Stukely. 4. That the supposed crocodiles found along with fish in the copper slate, or bituminous marl slate, of Thuringia, are reptiles of the genus monitor. 5. Lastly, that all these fossil remains of oviparous quadrupeds belong to very old flœtz strata, far older than the flœtz rocks that contain unknown genera of quadrupeds, such as the palæotheriums and anoplotheriums; which opinion, however, does not oppose the finding of the remains of crocodiles with those of these genera, as has been done in the gypsum quarries.*

Monitor.

In the well-known quarries of Maestricht there occur remains of a large fossil monitor. This species, which is one of the most celebrated of all the fossil species of oviparous quadrupeds, occurs in a soft limestone which contains flint, and the same kinds of petrifactions as are observed in the chalk near Paris. Even so early as the year 1766 it had engaged the attention of inquirers, and up to the present day has not ceased to be an object of discussion and investigation among naturalists. Some have described it as a crocodile, others as a whale; and it has even been arranged along with fishes. Cuvier, after

* Sir Everard Home has described, in the Transactions of the Royal Society of London for the year 1814, the fossil remains of an animal possessing characters partly of the crocodile, partly of the species of the class of fishes. It was found in a blue-coloured clayey limestone, named *Lias*, on the estate of Henry Host Henley, Esq. between Lyme and Charmouth, in Dorsetshire, and is now in the museum of Mr. Bullock of London.

a careful study of its osteology, ascertained that it must have formed an intermediate genus between those animals of the lizard tribe, which have a long and forked tongue, and those which have a short tongue and the palate armed with teeth. The length of the skeleton appears to have been nearly twenty-four feet. The head is a sixth of the whole length of the animal; a proportion approaching very near to that of the crocodile, but differing much from that of the monitor, the head of which animal forms hardly a twelfth part of the whole length. The tail must have been very strong, and its width at its extremity must have rendered it a most powerful oar, and have enabled the animal to have opposed the most agitated waters. From this circumstance, and from the other remains which accompany those of this animal, Cuvier is of opinion that it must have been an inhabitant of the ocean. We have here then an instance of an animal far surpassing in its size any of the animals of those genera to which it approaches the nearest in its general characters; at the same time, that, from its accompanying organic remains, we find reason to believe it to have been an inhabitant of the ocean, whilst none of the existing lizard tribe are known to live in salt water. However remarkable these circumstances are, still they are not more wonderful than those we contemplate in many of the numerous discoveries in the natural history of the ancient world. We have already seen a tapir of the size of an elephant; the megalonix, an animal of the sloth tribe, as large as a rhinoceros; and here we have a monitor possessing the magnitude of a crocodile.

Salamandra. Salamander.

In the valley of Altmühl, near Aichsted and Pappenheim, and also at Aeningen, there is a formation of calcarious slate rich in petrifactions. One of the most re-

markable of these is that described by Scheuchzer, under the name "Homme Fossile," and which some naturalists, as Gesner, maintained to be the siluris glanis of Linnæus, but which is, in reality, nothing more than an unknown, and probably extinct species of salamander or proteus. It was found imbedded in the limestone of Aeningen.

Bufo. Toad.

Fossil remains of an animal of this tribe occur in the slaty limestone of Aeningen. Dr. Karg, who has published a long description of the Aeningen quarries, is of opinion, that this petrifaction is that of a common toad; whereas Cuvier is inclined to refer it to some species nearly allied to the bufo calamita.

Fossil Saurus of Cuvier.

Only one specimen of this remarkable fossil animal has hitherto been found, and is now, I believe, in the cabinet of the King of Bavaria. It was formerly in the possession of Collini, and, according to the German journalists, was long concealed, to be out of the reach of the French, who, it is alleged, wished to secure for their own Museum so valuable an object of natural history. This is denied by M. Cuvier, who, in a letter to me on this subject, declares, that after the time of the Directory no plundering was authorized; on the contrary, that the French government rather bestowed donations than committed robberies.

In regard to this remarkable specimen, it may be remarked, that some naturalists have taken it for a bird, others for a bat, but Cuvier is of opinion that it belongs to the class amphibia. Its true nature is still unascer-

tained, although it appears more nearly allied to the class mammalia than to any of the others in the system.

CLASS.—PISCES.

Cuvier has not devoted much of his attention to the natural history of fossil fishes. He only mentions in a very general way, in his great work, the few genera met with in the gypsum quarries around Paris. Five species are mentioned. The first described belongs to a new genus allied to that named *amia*, and is conjectured to be a fresh water species. The second is nearly allied to two fresh water genera, viz. the *mormyrus* of La Cepide, natives of the river Nile, and the *pœcilia* of Bloch, natives of the fresh waters of Carolina. The third appears to be a species of *sparus*, different from any of the present species. The fourth and fifth are very dubious.

Osseous Conglomerate, or Breccia.

Cuvier gives a very interesting account of the osseous conglomerate, or breccia, which occurs in the rock of Gibraltar, and in other limestone rocks and hills upon the coasts of the Mediterranean.

This breccia occurs in a gray-coloured compact distinctly stratified flœtz limestone, which abounds in the islands and on the coasts of the Mediterranean. It is not intermixed with the limestone, nor does it alternate with it in beds, but occurs filling up fissures, or in caves situated in it. It is composed of angular fragments of the limestone, of bones, usually of ruminating animals, generally broken, and never in skeletons, and land shells, cemented together by a reddish brown coloured ochry calcarious basis. The base is sometimes vesicular, and

the vesicles are more or less completely filled with calcarious spar; and the spar sometimes traverses the conglomerate in the form of veins, or is more or less intermixed with it. Cuvier describes the osseous breccia of different tracts of country in the following order:—

1. *Gibraltar.*—The mineralogical nature of this famous rock is well known, from the excellent description of it by our countryman Colonel Imrie. It is principally composed of limestone, and is frequently traversed by fissures, or hollowed into caves, in which the osseous breccia is contained. Cuvier found in it the bones of a ruminating animal allied to the antelope, and of a smaller animal of the order glires, which he conjectures may belong to the genus lagomys. All the shells contained in the breccia are fresh water or land species.

2. *Cette.*—The breccia in this tract, like that of Gibraltar, occurs in limestone. In it Cuvier found bones of an animal not unlike the common rabbit; others of a species one-third less than the common rabbit; also bones of a species of mus, nearly allied to the field-mouse (mus arvalis, Lin.); of a bird of the order passeres; numerous vertebræ of a serpent somewhat resembling the coluber natrix; lastly, bones of a ruminating animal, probably of the same species as that found in the breccia of Gibraltar. Shells also occur. Three kinds are mentioned, viz. two helices, and one pupa, and all of them land-shells.

3. *Nice and Antibes.*—The limestone rocks of Nice contain this osseous breccia. Cuvier found in it bones of the horse, and of two species of ruminating animals. All the shells it contains are land species. The lime-

stone rocks of Antibes, near Nice, also contain osseous breccia, in which Cuvier found remains of ruminating animals, apparently the same as those of Nice.

4. *Corsica.*—The limestone rocks containing the osseous breccia occur near Bastia, and agree in all their characters with that of Gibraltar. The osseous remains are principally of smaller quadrupeds, but they do not, like those of Cette, belong to species now living in the surrounding country; for Cuvier discovered there the head of an animal nearly resembling the *lagomys alpinus*, a species which inhabits the wildest and most mountainous regions of Siberia, immediately under the snow line. He also found enormous quantities of the bones of a species of gnawer, somewhat resembling the mus terrestris of Linnæus, and of another very nearly allied to the water-rat.

5. *Dalmatia.*—The breccia is found throughout a great extent of limestone country. It agrees perfectly in its characters with that of Gibraltar. All the bones it contains, as far as Cuvier had an opportunity of examining, appear to be of the same size as those of the fallow-deer, and perhaps belong to the animal whose remains are found at Gibraltar. The remains of the horse have also been found in the breccia of this district; for the late John Hunter found the os hyoides of that animal in some masses of conglomerate from Dalmatia.

6. *Island of Cerigo.*—The only descriptions we have of this breccia, are those of Spallanzani and Fortis, from which it appears that it possesses the same characters as that of Gibraltar, &c. Spallanzani was of opinion that the bones belonged to the human species. Many years

ago Blumenbach refuted this opinion, and Cuvier shows that all of them belong to ruminating animals.

7. *Concud, near Teruel in Arragon.*—Bowles, in his Natural History of Spain, describes limestone rocks, containing an osseous breccia, as occurring at Concud. Cuvier is of opinion that it belongs to the same formation as that of Gibraltar. It contains bones of the ox, ass, of a small kind of sheep, and many terrestrial and fresh water shells.

8. *Osseous Incrustations in the Vicentine and Veronese.*—The natural history of these incrustations, or conglomerates, is still very imperfect. Cuvier found in them bones of the stag and ox.

Cuvier finishes his description of this osseous conglomerate, or breccia, with the following observations:

1. The osseous brecciæ have not be formed by either a tranquil sea, or by a sudden irruption of the sea. 2. They are even posterior to the last resting of the sea on our continent, since no traces are found in them of any sea-shells, and they are not covered by other beds. 3. The bones and the fragments of rock which they contain, fell into the rents of the rocks successively, and as they fell became united together by the accumulation of the sparry matter. 4. Almost all the fragments contained in the fissures are portions of the bounding rock. 5. All the well-ascertained bones belong to herbivorous animals. 6. The greater number belong to known animals, and to species that at present live in the neighbouring country. 7. The formation of these breccias, therefore, appears to be modern, in comparison of the flœtz rocks, and the alluvial strata, that contain remains of unknown land animals.

8. It is nevertheless still ancient, with respect to us, since nothing shows that such brecciæ are formed at the present day; and some of them, as those of Corsica, contain also the remains of unknown animals. 9. The most essential character of this phenomenon consists more in the facility with which certain rocks have been split, than the matters contained in the fissures. 10. This phenomenon is very different from that exhibited by the caverns in Germany, which contain the bones of carnivorous animals only, spread over the bottom, in an earthy tuff, partly of an animal and partly of a mineral nature; although the rocks in which these caverns are situated do not appear to be very different from those which contain the osseous brecciæ.

Note K (b.) § 28. p. 103.

Mineralogical Description of the Country around Paris.

As the very short account of the mineralogy of the country around Paris, in Note K (a), may not prove satisfactory to those who wish a more particular detail, we here insert a description, which, with the assistance of the plate, (Plate IV.) will, we trust, enable the reader to form a distinct conception of all the important features of that remarkable district.*

The country in the environs of Paris is entirely composed of newer flœtz rocks, of which the oldest, or lowest, is common chalk; the uppermost, or newest, alluvial. Interposed between these are nine different formations, principally of limestone, sandstone, and gypsum. The whole series of formations, according to Cuvier and

* The description is drawn up in conformity with the observations of Cuvier and Brongniart, in their valuable work, entitled "Essai sur la Geographie Mineralogique des Environs de Paris." 4to. 1811.

Brongniart, appear to be arranged in the following order, from below upwards.

1. The chalk formation, with flint.

2. Plastic clay, with sand (*argile plastique.*)

3. Coarse marine limestone (*calcaire grossier*), with its marine sandstone (*gres marine inferieur.*)

4. Siliceous limestone (*calcaire silicieux*).

5. Gypsum and marl, containing bones of animals (*marnes du gypse d'ossements.*)

6. Marine marl, abounding in bivalve shells; and the upper layers, abounding in oyster shells.

7. Sandstone and sand, without shells.

8. Upper marine sandstone (*gres marine superieur.*)

9. Millstone, or buhrstone, without shells (*meuliere sans coquilles.*)

10. Flint and siliceous limestone or the upper or second fresh water formation, millstone, flint, and limestone (*terrein d'eau douce superieur, meuliere, silex, et calcaire.*)

11. Older and newer alluvial deposites (*Limon d'atterrissement.*)

First Formation.

Marine Origin.

Chalk.

This chalk agrees, in external characters, with that found in other countries. It occurs in indistinct horizontal strata, in which we observe either interrupted layers or tuberose shaped masses of flint, which pass into the chalk at their line of junction, or kidneys of hard chalk, having the same shape and position with the flint. This formation is well characterized by the petrifactions it contains, which differ not only in the species, but sometimes

also in the genus, from those that occur in the *coarse limestone*. Two species of belemnite occur in the chalk, and these appear to be different from those found in the limestone, and are considered to characterize it.

The chalk forms the bottom of the basin or gulf, in which are deposited the different formations that occur around Paris. Its surface must have presented numerous inequalities before the present strata were deposited over it, because we observe promontories and islands of chalk rising through the newer formations.

Second Formation.

*Fresh water Origin.**

Plastic Clay.

All around Paris, we find the chalk covered with a deposite of plastic clay, which is dug and used in the manufacture of different kinds of pottery. This clay varies in colour, being white, gray, yellow, red, and black, sometimes contains a layer of sand, very rarely (only the purer varieties) organic remains, viz. cytherea, turtellæ, bituminous wood, and in some places fragments of chalk have been observed in it. It is neither intermixed with the chalk at its line of junction with it, nor is it more calcarious where in contact with that mineral, than at a distance from it; hence Cuvier conjectures, that it has been deposited after the chalk, and is therefore a separate formation.

* I designate the formations *fresh water and marine*, according to the idea of Cuvier and Brongniart; although I do not agree with these philosophers in their opinion of the alternate play of salt and fresh water.

Third Formation.

Marine Origin.

Coarse Marine Limestone, with its Marine Sandstone.

This formation presents much greater variety than the chalk. Several different strata, or series of strata, such as limestone, clay-marl, limestone-marl, slate-clay, occur in it. These are arranged in a determinate order, and the strata of limestone are well characterized by their geognostic characters and by the petrifactions they contain; the same system of strata always possessing the same general characters and species of petrifactions.

First System of Strata.

The lowest system of strata, or first system of strata, of the coarse limestone formation, is very sandy, and sometimes contains a substance resembling green earth ; it is still better characterized by containing a great variety of well preserved shells, many of which still retain the pearly lustre, and differ more from the present existing species, than those in the upper strata of this formation. It is particularly characterized by the nummulites it contains.

The following are the petrifactions enumerated by Cuvier and Brongniart, as occurring in it.

Nummulites lævigata
scabra
numismalis — These are always found in the lowest part of the bed.

Madrepora—At least three species.
Astræa—Three species at least.
Carophyllia—Three simple, and one branched species.
Fungites.

Cerithum giganteum.
Lucina lamellosa.
Cardium porulosum.
Voluta cithara.
Crassatella lamellosa.
Turritella multisulcata.
Ostrea flabellula.
Cymbula.

Second System of Strata.

The limestone of these strata is of a grayish yellow colour, is in part oolitic, or composed of small roundish grains, and contains remarkable cotemporaneous cavities, that traverse the strata, and which are filled with loam, sand, and flint. It is still very rich in shells; nearly all the bivalves found by M. Defrance at Grignon belong to it. It also contains a few impressions of leaves and stems of vegetables, and *single fresh-water shells.* The most characteristic petrifactions of this system of strata are the following.

Cardita avicularia.
Orbitolites plana.
Turritella imbricata.
Terebellum convolutum.
Calyptræa trochiformis.
Pectunculus pulvinatus.
Citheræa nitidula.
elegans.
Miliolites—It is very abundant.
Cerithium—Probably several species; but neither the lapidum and petricolum, nor cinctum and plicatum, which latter belong to the second marine formation which covers the gypsum.

Of these petrifactions, the most characteristic is the cerites.

*Third System of Strata.**

The third system of strata is already less abundant in petrifactions, and contains fewer species than the two preceding. The following have been observed.

Miliolites—Very rare.
Cardium Lima, et obliquum.
Lucina saxorum.
Ampullaria spirata.
Cerithium tuberculatum.
   mutabile.
   lapidum.
   petricolum.
} Almost all the other species, with exception of the giganteum.
Corbula anatina?
   striata.
Also impressions of the leaves of a fucus.

The strata of the second and third systems sometimes contain beds of sandstone, or masses of hornstone filled with marine shells. In some cases the sandstone takes the place of the limestone. *Land shells and fresh-water shells (Limnœa et Cyclostomœ)* have also been observed in this sandstone. The sandstone and the hornstone, containing marine shells, rest either immediately on the marine limestone, or are contained in it. The following list contains the names of those species of petrifactions which occur most frequently in the sandstone.

Calyptræa trochiformis?
Oliva laumontiana.

* This is the limestone used for building at Paris.

Ancilla canalifera.
Voluta harpula.
Fusis bulbiformis.
Cerithium serratum.
  tuberculosum.
  coronatum.
  lapidum.
  mutabile.
Ampullaria acuta, or spirati.
  patula.
Nucula deltoidea.
Cardium lima.
Venericardia imbricata.
Cytherea nitidula.
  elegans.
  tellinaria.
Venus callosa?
Lucina circinaria.
  saxorum.
Two species of oyster still undetermined; the one appears allied to *ostrea deltoidea,* the other to *ostrea cymbula.*

Fourth System of Strata.

This set of strata consists of hard calcarious marl, soft calcarious marl, clayey marl, and calcarious sand, which is sometimes agglutinated, and contains horizontal layers of hornstone, crystals of quartz, and rhomboïdal crystals of calcarious spar, and small cubical crystals of fluor spar. Petrifactions occur very rarely.

Fourth Formation.

Siliceous Limestone without Shells.

This formation occurs alongside the coarse marine limestone, on the same level with it, and in no instance

either above or below it. It rests immediately on the plastic clay. It consists of strata, not only of a white limestone, but also of a gray, compact, or fine granular limestone, which is penetrated in all directions with silica; and its numerous cavities are lined with siliceous stalactites, or quartz crystals. It is destitute of petrifactions. A species of millstone sometimes occurs in it, which appears to be the siliceous limestone deprived of its calcarious ingredient by some agent unknown to us. This rock is scarcely entitled to the rank of a distinct formation: it appears to be one of the members of the preceding series without petrifactions. It may be remarked that it is not uncommon to observe in the same formation beds with and without petrifactions.

Fifth and Sixth Formations.

Fresh Water and Marine Origin.

Gypsum Formation, and the Marine Marl Formation.

This formation is not entirely of gypsum, but contains also beds of clay marl and calcarious marl. These are arranged in a determinate order when they all occur together, which, however, is not always the case. They lie over the coarse marine limestone; and the gypsum, which is the principal mass of the formation, does not occur in wide extended plateaus, like the limestone, but in single conical or longish masses, which are sometimes of considerable extent, but always sharply bounded. Montmartre presents the best example of the whole members of the formation, and there three beds of gypsum are to be observed superimposed on each other.

The *first bed* consists of alternate layers of gypsum solid calcarious marl, and of thin slaty argillaceous marl or adhesive slate. The layers of gypsum are thin, and

full of selenite crystals; and in the clay marl or adhesive slate, occurs imbedded menilite. *Marine shells* occur in several of the layers of the marl, and it is remarked that wherever the gypsum rests immediately on the sand of the marine sandstone containing shells, it contains sea shells. The former bottom of the sea, however, appears to have been frequently covered with a bed of white marl, on which the lower beds of gypsum rest, and this bed is filled with fresh-water shells. The *second bed* resembles the first, and only differs from it in being thicker, and containing fewer beds of marl. The only petrifactions it contains are those of fishes; but it encloses masses of celestine, or sulphat of strontian. The *third*, or *upper bed*, is by far the greatest, being in several places more than sixty feet thick. It contains few beds of marl; and in some places, as at Montmorency, it lies almost immediately under the soil. The lower strata of this upper gypsum contain flint, which appears to be intermixed with it, and to pass into it by imperceptible gradations—facts which show their cotemporaneous formation. The middle strata of this bed split naturally into large prismatic concretions, with many sides. The uppermost strata, of which five generally occur, and extend to a great distance, are thinner than the others, and are intermixed with marl, and also alternate with beds of it.

Numerous quarries are situated in this upper gypsum, and which daily afford skeletons, or single bones of unknown birds and quadrupeds. To the north of Paris these are found in gypsum itself, where they are hard, and simply invested with marl; and to the south of Paris similar remains, but in a friable state, are met with in the marl which separates the beds of gypsum. Bones of tortoises, and skeletons of fish, are found in the same bed, and more rarely fresh-water shells of the genus cy-

clostoma. This latter fact, Cuvier remarks, shows the plausibility of the opinion of Lamanon, and other naturalists, who maintain, that the gypsums of Montmartre, and other hills in the basin of Paris, have been deposited from fresh-water lakes. The occurrence of skeletons of quadrupeds particularly characterizes the upper bed of gypsum, because remains of the same nature have not hitherto been discovered in the middle or lower beds of gypsum.

Beds of calcarious and clayey marl rest immediately over the gypsum. Woodstone, or petrified wood of a kind of palm tree, occurs in a white friable chalky marl; and in quarries which are worked in it, remains of fishes and of shells, of the genera lymnæus, and planorbis, are met with. The two latter do not differ very much from those found in the marshes in France,—a fact which seems, in the opinion of Cuvier, to show, that this marl, as well as the subjacent gypsum, have been deposited from fresh water. In the numerous and thick beds of clayey and calcarious marl which rest over this white friable chalky marl, petrifactions are so rare, that we cannot form any satisfactory opinion as to their formation.

Over the beds of clayey and calcarious marl there rests a bed of yellowish slaty marl, three feet three inches thick. Kidneys of earthy calestine occur in the lower part of it; somewhat higher up we meet with a bed of small bivalve shells, which are referred to the genus Citherea, and between the uppermost layers of the marl other species of citherea, with cerites spirobites, and bones of fish, occur. This bed is not only remarkable on account of its great extent, (it has been traced ten leagues in one direction, and four leagues in another,

and throughout its whole extent of the same thickness), but also because it is considered as marking the upper boundary of the first fresh water formation, and the beginning of a new *marine formation*. All the shells that occur in the marl above this bed belong to the ocean.

A great bed of greenish clayey marl, without petrifactions, rests immediately over the yellowish marl, and contains kidneys of clayey calcarious marl, and also of celestine. Immediately over these follows a bed of yellow clay-marl, which abounds in fragments of marine bivalve shells, cerites, trochites, mactrites, cardites, venites, &c. and fragments of the tail of two species of ray have also been found in it.

The beds of marl which rest over these contain principally bivalve marine shells; and in the uppermost bed of calcarious marl, immediately under the clayey sand, there occur two distinct beds of *oysters*, of which the undermost contains large and thick oysters, and the upper, which is sometimes separated from the under by a thin bed of white marl, without shells, numerous, small, thin, and brown oyster shells. This latter bed of oysters is very thick, is divided into many layers, and is scarcely ever wanting in the hills of gypsum.

These oysters appear to have lived on the spot where we at present find them, because they are arranged as we find them in oyster banks in the ocean; and the greater number of them are whole, and with both valves. Lastly, M. Defrance found, near Roquencourt, at the height of the formation of the marine gypseous marl, rounded fragments of marly shell limestone, pierced with pholades, and with oyster shells attached to them. The

formations sometimes terminate with a bed of clayey sand, in which no petrifactions occur.

The whole of the beds, from the layer immediately over the marine limestone, to that containing the oysters, constitute the gypsum formation. Cuvier considers them as constituting two formations, viz. the gypsum and marine marl formations. It is, however, evident that all the beds belong to one formation, because they exhibit all those relations which occur in sets of strata, considered as belonging to the same formation.

In the following Table are enumerated the petrifactions that belong to the gypsum, and to the marine formation which rests on it.

Petrifactions of the Gypsum and the Marine Marl resting upon it.

FRESH WATER FORMATION.

Fossil quadrupeds in gypsum - -	Palæotherium magnum.
	medium.
	crassum.
	curtum.
	minus.
	Anoplotherium commune.
	secundarium.
	medium.
	minus.
	minimum.
	A pachidermatous animal, allied to the hog.
	Canis Parisiensis.
	Didelphis Parisiensis.
	Viverra Parisiensis.
Birds - - - - -	Three or four species.
Reptiles - - - -	Trionix Parisiensis, and another tortoise.
	A species of saurius, which appears to be a crocodile.
Fishes - - - -	Three or four species.
Molluscous animals	Cyclostoma mumia.
Upper white marl	Palms.
	Fragments of fishes.
	Limneus.
	Planorbes.

MARINE FORMATION.

Slaty yellow marl.	Cytherée bombée.	The shells of these petrifactions are generally in a powdery state, or we have only their mould or impression.
	Spirobes.	
	Bones of fishes.	
	Cerithium plicatum.	
	Cytherée planes.	
	Bones of fish.	

Green marl.	No fish.	
Yellow marl, mixed with brown slaty marl.	Parts of the ray. Ampullaria patula? Cerithium plicatum. cinctum. Cytherea elegens. semisulata. Cardium obliquum. Nacula margaritacea.	Almost all these shells are broken, and difficult to ascertain. The two species of cerites of the marine formation, which covers the gypsum, do not appear to occur any where else.
Calcarious marl, containing large oysters.	Ostrea hippopus. pseudochama. longirostris. canalis.	The two beds of oysters are often separated from each other by marl without shells; and although we cannot say with any certainty whether or not the particular species here enumerated are shells that belong more to the one bed than to the other; yet it cannot be doubted, that the oysters of this marl do not occur in the coarse limestone, and that they are more nearly allied to the species at present living in our seas, than to those found in the limestone.
Calcarious marl, containing small oysters.	Ostrea cochlearia. cyathula. spatulata. linguatula. Ballanites. Shells of crabs.	

Seventh Formation.

Of Sandstone and Sand without Shells.

The sandstone with shells is one of the latest formations. It always rests on those already described, and in general is only covered with the millstone without shells, and the upper fresh water formation.* Its strata are often of considerable thickness, are intermixed with beds of sand of the same nature, and both are often so fine that they are used in manufactories.

Eighth Formation.

Marine Origin.

Upper Marine Sandstone and Sand.

This sandstone, or last marine formation, rests on the gypsum, marine marl, and even upon the sandstone and sand without shells. It varies in colour, compactness, and even in composition. Sometimes it is a pure sandstone, but friable, and of a red colour, as at Montmartre; sometimes it is a red coloured clayey sandstone, as at Romainville; sometimes it is a grayish sandstone, as at Levignan; lastly, its place is occasionally occupied with a thin bed of calcarious sand filled with shells, which covers the great masses of gray, hard sandstone, and without shells, at Nanteiulle-Haudouin.

This sandstone contains marine shells, which are sometimes different from those found in the sandstone of the lower marine formation, and approach more to the species met with in the calcarious marl, which surmounts

* It appears, as we shall afterwards show, that it is in some places covered by a formation of marine sandstone or limestone.

the gypsum, as will appear from the following enumeration.

Shells found in the Upper Marine Sandstone.

Oliva mitriola.
Fussus? allied to longævus.
Cerithium cristatum.
  lamellosum.
  mutabile?
Solarium? Lam. Pl. viii. fig. 7.
Melania costellata?
Melania?
Pectunculus pulvinatus.
Crassatella compressa.
Donax retusa?
Citherea nitidula.
  lævigata.
  elegans?
Corbula rugosa.
Ostrea flabellula.

This formation, and the one preceding it, although arranged by Cuvier and Brongniart as distinct formations, are evidently members of one and the same formation.

Ninth Formation.

Millstone without Shells.

This formation consists of iron-shot clayey sand, greenish, reddish, and whitish clay marl, and *millstone;* and although separated by Cuvier from the flint and siliceous limestone formation, appears to be a member of that series. This millstone is a quartz, containing a multitude of irregular cavities which are traversed by siliceous

fibres, disposed somewhat like the reticular texture in bones. These cavities are sometimes lined or filled with red ochre, clay marl, or clayey sand, and they have no communication with each other. Most of the millstones found around Paris have a red or yellowish tint, but the rarer and most esteemed varieties have a bluish shade of colour. The bluish variety is the most highly prized, because it affords the whitest coloured flour; and a millstone of this kind, six feet and a half in diameter, sells at 1200 francs. We never observe in its cavities any silice ous stalactites, orcry stallized quartz; and this character enables us to distinguish, in hand specimens, this millstone from that found in the siliceous limestone. It is sometimes compact. It has been analyzed by Hecht in the Journal des Mines, No. xxii. p. 333, and appears to be almost entirely composed of silicea. Another geognostic character of the millstone, properly so called, is the absence of all fossil animal and vegetable productions, whether of fresh or salt water origin.

It often rests on a bed of clay marl, which appears to belong to the gypsum formation; in some places it is separated from it by a bed varying in thickness, of sandstone or sand without shells. It is sometimes immediately covered with vegetable earth, but in other instances it has resting on it the upper fresh water formation, or the alluvial formation.*

* The most extensive mass of this millstone occurs in the plateau which extends from La Ferte sous Jouarre (on the Marne, 16 leagues east from Paris) nearly to Montmirail; and here, near the first town, it has been quarried upwards of four hundred years for the excellent millstones it affords. The lower part of the plateau is marine limestone; the upper part, on the edges, and toward the Marne, of marl and gypsum; but in the middle, of an iron-shot and clayey sand, which forms a bed upwards of 60 feet thick. The millstone occurs in this great bed

Tenth Formation.

Fresh water Origin.

The Flint and Siliceous Limestone Formation.

We have already described a formation which, according to Cuvier, has been deposited from fresh water, because the fossil animals it contains are analogous to those we find in our fresh water lakes. This formation, which consists of gypsum and marl, is separated from another and more superficial fresh water formation, of which we are now to give an account, by the upper marine sandstone already described.

The second fresh water formation, in the vicinity of Paris, consists of two sorts of stone, flint and siliceous limestone. These substances sometimes occur independent of each other; in other instances they are intimately mixed together. The nearly pure limestone is the most common; the next in frequency is a mixture of flint and limestone; but large masses of pure flint are the rarest.

---

of sand, extends nearly throughout the whole plateau, and varies in thickness from three to five fathoms; but millstones cannot be made of every portion of the mass; hence we must not expect to find it throughout the whole bed. A bed of rolled masses of millstone, about a foot and half thick, lies over it; over this a thin bed of iron-shot sand, containing smaller pieces of millstone, and above this bed is one of sand, from 12 to 17 yards thick. If the stone rings when struck with a hammer, it will answer for large millstones. The bed never affords more than three millstones in the direction of its thickness. It frequently happens, that the fissures allow the workmen to extract the masses in a perpendicular direction, and these are the best. Millstones are formed by joining many of these parallelopipedal pieces together, and confining the whole with an iron hoop. These pieces are exported from France, to England and America.

The flint is sometimes nearly pure; sometimes approaches to pitchstone or to jasper and quartz; and, lastly, it has a corroded shape when it has all the characters of true millstone, but which is in general more compact than the millstone without shells. The limestone of this formation is white or yellowish-gray; sometimes nearly friable, like marl or chalk; sometimes compact and solid, with a fine grain and conchoidal fracture: the conchoidal varieties are rather hard, but easily broken into sharp-edged fragments, somewhat like flint. These characters apply only to the limestone near Paris; for, at a considerable distance, the limestone occurs very compact, of a grayish-brown colour, and which readily cuts and polishes. The limestone of Mont-Abusar, near Orleans, which contains bones of the Palæotherium, belongs to this formation. Even the hardest varieties of this limestone, after exposure to the air for a time, soften; and hence it is used as a marl for manuring the ground. All the varieties, both hard and soft, are traversed by empty vermicular cavities, whose walls are sometimes of a pale green colour. Where the siliceous minerals and the limestone are intermixed, the latter is always corroded, full of cavities, and its irregular cells are filled with calcarious marl. The essential character of this formation is, that it contains fresh water and land shells, nearly all of which belong to genera that now live in our morasses, but no marine shells; at least in such places as are distant from the subjacent marine formation. The following is a list of those fossil organic remains that belong particularly to the upper fresh water formation.

Cyclostoma elegans antiquum.
Potamides Lamarkii.
Planorbis rotundatus.
          cornu.

Planorbis prevostinus.
Limneus corneus.
fabulum.
ventricosus.
inflatus.
Bulimus pygmeus.
terebra.
Pupa Defrancii.
Helix Lamani.
Desmarestina.
Dicotyledonous wood, petrified with silica.
Stems of arundo or tipha.
Articulated stems, resembling the thorn.
Peniculated ovoidal grains.
Canaliculated cylindrical grains.
Olive-shaped bodies, with an irregular streaked surface.

The potamides, helicites, and limneus corneus, are the petrifactions that most frequently characterize this second fresh water formation, and the cyclostoma mumia has never been found in it. The first or lowest fresh water formation, on the contrary, has its characteristic petrifactions, the cyclostoma mumia, and Limneus longiscatus, and palludinus, but it never contains potamides, or helicites. It is remarkable that no bivalve shells occur in this formation, and that it contains numerous small roundish groved bodies named Gyrogonites, which appear to be the fruit of a marsh plant of the Chara tribe.

This second fresh water formation extends for thirty leagues to the south of Paris, and has also been met with in the department of Cher, Alliere, Nievre, Cantal, Puy de Dome, Tarn, Lot, and Garonne, in the southeast of France, and more lately the same interesting formation has been discovered in the Roman states, in Tuscany, and

in the vicinity of Ulm, Mayence, Silesia, in Estremadura, near Burgos, and other places in Spain.

From the few observations we have made in the course of our enumeration of the formations of Cuvier, it appears that some of his distinctions are unnecessary, and that the whole of the formations may be more satisfactorily arranged in the following manner: 1. Chalk. 2. Plastic clay. 3. Limestone. 4. Gypsum. 5. Sandstone. 6. Flint and siliceous limestone. The names salt and fresh water formations being hypothetical, ought to be abandoned, and others expressive of some of the characters of the formation adopted in their stead.

Eleventh Formation.

Alluvial.

This appears also to be a deposite from fresh water. It consists of sand of many different colours, marl, clay, and even of mixtures of the whole three, which is intermixed, and coloured brown and black with carbonaceous matter, also of rolled masses of different kinds; and what particularly characterizes it, large trunks of trees, and bones of elephants, oxen, deer, and other large mammalia. Although this formation is new, in comparison of those we have just described, yet it is of high antiquity in regard to man, as its formation extends to a period not far removed from the earliest periods of our history, when the earth supported vegetables and animals different from those that at present live in these or any other countries on the globe. The alluvial substances around Paris occur in two different situations, viz. *first*, in the present valleys; and, *secondly*, on the plains. In valleys they either cover the bottom, and then they consist of sand, loam, or peat; or they form in them wide

extended plains, which lie high above the present river courses, and then they oonsist of gravel and sand. it is difficult to distinguish the alluvial mud, situated at a distance from the valleys, from the fresh water formations, and it even, in some places, seems to pass into it. It appears, however, to be older than that of the valleys.

General Observations.

The eleven different formations now described are considered by Cuvier and Brongniart to be partly of marine, partly of fresh water origin, these distinctions depending on their containing salt or fresh water petrifactions. On this principle the formations are viewed as follows:

Formation.	*Origin.*
1. Chalk.	Marine
2. Plastic clay, &c.	Fresh water.
3. Coarse marine limestone.	Marine.
4. Siliceous limestone without shells.	Not determined.
5. *a.* Marl at the bottom of the gypsum formation.	Fresh water.
b. The layers of marl, gypsum, and adhesive slate above the preceding.	Marine.
c. The great bed of gypsum.	Fresh water.
6. Marine marl above the great bed of gypsum.	Marine.
7. Sandstone and sand without shell.	Not determined.
8. Marine sandstone and sand.	Marine.
9. Millstone without shells.	Not determined.
10. Flint siliceous limestone.	Fresh water.

The marine formations are conjectured to have been deposited from the waters of the ocean, but the fresh water rocks from the waters of lakes. This hypothesis supposes an alternate flux and reflux of the waters of the ocean, and an appearance and disappearance of the waters of lakes. However amusing such an hypothesis may be, we must confess that it is not consistent with the usual course of nature in the mineral kingdom, and that it is also contradicted by the geognostical relations of the individual formations themselves. In describing a formation, we cannot rest satisfied with the mere enumeration and description of the organic remains it contains; these alone will never enable us to characterize it as an unity in the great series of rock formations: in order to determine it with accuracy, we must state the characters of each individual bed, describe the imbedded and venigenous minerals they contain, the relation of the beds to each other, in regard to position, transition, intermixtures, &c., and lastly describe the fossil organic remains enclosed in it. But this is not exactly the method followed by M. Cuvier and Brongniart; they seem to consider the fossil organic remains as affording characters of superior importance to all the others; in short, that from them alone the principal and sole distinction amongst flœtz formations are to be made. Thus the gypsum formation in its lowest part, where it rests on the marine limestone, contains fresh water organic remains; hence it is said to be a fresh water deposite; the part of the same formation immediately above this contains salt water petrifactions, it is therefore formed from the waters of the ocean; the thick bed of gypsum in the middle and upper part of the formation, from its containing remains of fresh water shells and of quadrupeds, is another fresh water formation; and the uppermost part of the formation, the marine marl, from the nature of its organic remains, is maintained to

be a deposite from the ocean. But we have only to read Cuvier and Brogniart's description of this set of rocks to be convinced, that all the strata and beds of which it is composed, from the low marl resting on the limestone to that immediately under the marine sandstone, have those mutual relations and agreements observable in every well characterized formation, thus proving that all of them have been formed by the same process and from the same fluid.

But in most of these fresh and salt water formations we find an intermixture of both classes of remains, the fresh water and salt water, a fact which shows the insufficiency of the distinctions attempted to be established. To Cuvier and Brongniart we are indebted for much valuable information in their description of the country around Paris, but we must protest against the use they have made of fossil organic remains in their geognostical descriptions and investigations. They have too often lost sight of the mineralogical relations of the rocks, and wish to fix the attention of naturalists principally on the organic remains. Thus, in some degree, separating what must always be conjoined when we wish to describe rocks and characterize formations.

Several of these new flœtz formations, as already mentioned, have been discovered in other parts of Europe; and we may now add, that lately a series of rocks of the same general nature has been observed resting on the chalk formation in the south of England. The newer formations in this island were first pointed out, and described by Mr. Webster, in a valuable Memoir in the second volume of the Transactions of the Geological Society. That gentleman is of opinion, that two basins of chalk, filled with the newer formations, occur in the southern

parts of England; one he names the Isle of Wight Basin, the other the London Basin.

1. *Isle of Wight Basin.*

The southern side of this basin extends from the highly inclined chalk at the Culver cliffs, at the east end of the Isle of Wight, to White Nose, in Dorsetshire, five miles west of Lulworth. The north side of it may be traced in that range of hills called the South Downs, extending from Beachy Head, in Sussex, to Dorchester, in Dorsetshire. The strata of which these hills are composed, dip generally from 15° to 5° to the south; the inclination varying in different places. The south side of the basin, therefore, must have been extremely steep, while the slope of the north side was very gentle. The closing of the basin at the west cannot be distinctly traced; but the east is now entirely open, the sea passing through it.

2: *London Basin.*

The south side of the basin is formed by a long line of chalk hills, including those of Kent, Surry, Hampshire, called the North Downs, extending through Basingstock to some distance beyond Highclere Hill, in Berkshire. Its western extremity is much contracted, and seems to lie somewhere in the vicinity of Hungerford. Its northwestern side is formed by the chalk hills of Wiltshire, Berkshire, Oxfordshire, Buckinghamshire, and Hertfordshire. The most southern part of this boundary has not yet been well determined. On the east it is open to the sea, the coasts of Essex, Suffolk, and Norfolk, being sections of the strata deposited in it. The dip of the chalk of the North Downs, from Dover to Guilford, is from 15° to 10°; but in the narrow ridge of chalk, called the Hog's Back, extending from Guilford to Farnham, the

dip is very considerable, being about 45°. On the dip of the other sides, no observations have hitherto been made. The depth of the chalk below the surface at London must be very considerable; since, though wells have been sunk several hundred feet, it has never been reached; but at a few miles south of the metropolis, the chalk is frequently come to.

The formations described by Mr. Webster as lying over the chalk, and in these basins in the south of England, are the following:

1. The lowest marine formation over the chalk, including the plastic clay, and sand, together with a particular clay, named the *London Clay*.
2. The lower fresh water formation, which rests immediately on the preceding formation.
3. The upper marine formation.
4. The upper fresh water formation.
5. Alluvium.

Chalk Formation.—The chalk which forms the sides and bottom of the basins, occurs distinctly stratified, and the strata vary in thickness from a few inches to several feet. The whole formation may be considered as composed of three great stratified beds, the undermost of which is named *chalk marl;* the second *hard chalk*, without flint; the third or uppermost, *soft chalk*, with flint. The *chalk marl* varies in colour, being gray, yellowish, brown: it is softer than true chalk, and on exposure to the weather it rapidly disintegrates. It contains cotemporaneous nodules, and also beds of a more indurated marl, named *gray chalk*, from its dark colour. Like all argillaceous limestones, it possesses, in a considerable degree, the property of setting under water, when calcined

and made into mortar. It contains the following petrifactions, viz. ammonites, scaphites, turrellites, trochites, and madreporites. The middle bed, the *hard chalk*, is in general harder than the bed above it, although Mr. Webster remarks, that it appears from some observations he made in Dorsetshire, that the hardness does not always mark a particular bed, the flint chalk being in some places much harder than that without flints in others. It contains a greater variety of petrifactions than the chalk marl, as appears from the following list of the genera observed by Mr. Webster. Several echini of the same families as those met with in the chalk with flint; but many of them, particularly the cassides, differing much in their forms from those found in that bed. Spines of echini; and particularly those described by Brard as resembling the Belemnites. Patellites. Trochites. Serpulites, several species. Belemnites. Lima? Fish, too much mutilated to ascertain the genus. Palates, scales, vertebræ, and teeth of fish. Cancri.—The upper bed, the *soft chalk with flints*, forms the upper part of the formation, and is distinguished from the preceding by its softness, and always containing flints. It also differs from it in the petrifactions it contains, of which the following are enumerated by Mr. Webster. Asteriæ. Echini of several families. Spines of the foregoing, resembling belemnites. Serpulites. Cardium. Spondylus. Ostrea, several species. Pecten, several species. Chama? Terebretula, many species. Alcyonia, sponges, and numerous unknown zoophytes. A ramose madrepore. Several species of minute encrini, figured by Mr. Parkinson.

1. *Lower Marine Formation.*

This formation is separated into two great divisions, 1. Sand and plastic clay. 2. London clay.

1. *Sand and Plastic Clay.*—Of these two minerals the sand is the most extensive and continuous, and the clay occurs filling up basins and hollows in it. The clay varies in colour, being white, gray, yellowish-brown, and red. The white and gray varieties are potters' clay. It sometimes contains beds of brown coal, from one foot to three feet thick; and beds of ironstone, and ferruginous sand, occur connected with it, and generally lying over it.

2. *London or Blue Clay.*—The bed which has received this name, is found immediately under the gravelly soil on which London is situated. Of all the strata over the chalk in the south of England, it is of the greatest extent and thickness; and the number, beauty, and variety of the petrifactions which it contains, render it the most interesting, and the most easily distinguishable. It consists generally of a blackish clay, sometimes very tough, and occasionally mixed with green earth and sand, or with calcarious matter. It contains also numerous flat spheroidal cotemporaneous nodules of hard marl, or clayey limestone, which lie in regular horizontal layers, at unequal distances, generally from four to forty feet apart. These nodules are well known by the name of Ludus Helmontii, or Septaria, from their being divided across by partitions or veins of calcarious spar, which are generally double. In their cavities are frequently found crystals of calcarious spar, and of heavy spar. The septaria are surrounded by crusts which contain a smaller proportion of carbonate of lime than the central part. They often contain organic remains.

Besides the clay, marl, sand, and carbonate of lime, of which the main body of this bed consists, several other substances are dispersed through it in smaller quantities.

Of these the chief is iron pyrites, which is frequently the mineralizing matter both of the vegetable and animal remains included in the blue clay. Selenite is also very abundant; and sulphat of iron sometimes effloresces, when the clay is exposed to the air, from the decomposition of the pyrites contained in it. Phosphat of iron is also sometimes found; and it abounds in Epsom salt, and in fossil organic remains.

In some places, as at Bognor, it assumes a new character; instead of a blue clay, we find a number of rocks now appearing as detached masses in the sea, though evidently forming portions of a stratum once continuous. The lowest part of these rocks is a dark gray limestone, or perhaps rather a sandstone, containing much calcarious matter, enclosing many organic remains belonging to the blue clay. The upper part is siliceous sandstone.

This clay abounds in petrifactions, and of those the following copious list is given in Mr. Webster's paper:

Organic Remains in the Lower Marine Formation above the Chalk in England.

NAMES GIVEN BY LAMARCK.	LINNÆAN NAMES.
Astroitæ.	Astroitæ.
Calyptrea trochiformis.	Trochus apertus. Brander.
Conus.	Conus.
Cyprea pediculus.	Cyprea pediculus.
Terebellum convolutum.	Bulla sopita. Brander.
Oliva.	Voluta.
Voluta spinosa.	Strombus spinosus.
musicalis.	luctator.
bicorona.	ambiguus.
crenulata.	Murex suspensus.

NAMES GIVEN BY LAMARCK.	LINNÆAN NAMES.
Buccinum undatum.	
Harpa.	
Cassis carinata.	Buccinum nodosum. Brand.
Rostellaria macroptera.	Strombus amplus.
Murex tripterus.	Murex tripterus.
tricarinatus.	asper.
tubifer.	pungens.
	contrarius.
	whirls the right way.
Fusus longævus.	longævus.
Murex clavellatus.	Murex deformis.
rugosus.	porrectus.
Pyrula nexilis.	nexilis.
Pleurotoma ?	
Cerithium gigantum.	Murex.
Cerithium, another variety, but too mutilated to ascertain the species.	Murex.
Trochus agglutinans.	Trochus umbilicaris. Brand.
monilifer.	nodulosus.
Solarium caniculatum.	Turbo, tab. 1. fig. 7 & 8. Brander.
or	
Delphinula ?	Turbo, tab. 1. fig. 7. Brand.
Turritella terebellatta.	Turbo terebra.
imbricatoria.	editus.
multisulcata.	vagus.
Ampullaria patula.	Helix mutabilis.
Dentalium elephantinum.	Dentalium elephantium.
entalis.	entalis.
dentalis.	dentalis.
straitulum.	straitulum.
Serpula.	Serpula.
Nautilus imperialis.	
pompilius.	

NAMES GIVEN BY LAMARCK.	LINNÆAN NAMES.
Nautilus centralis.	
Lenticulina rotulata.	
Nummulites lævigata.	
Pinna, 2 species.	Pinna.
Mytilus modiola.	Mytilus.
Pectunculus pulvinatus.	Arca glycemeris.
	noæ.
Cardium porulosum.	Cardium porulosum.
asperulum.	asperulum.
obliquum.	obliquum.
Crassatellata lamellosa.	Tellina sulcata.
Venericardia planicosta.	
Capso rugosa.	Venus deflorata.
Chama lamellosa.	Chama squamosa.
calcarata.	
sulcata.	
Ostrea edulis.	Ostrea edulis.
Pyrus bulbiformis.	
Caryophillia.	Turbinated madrepores.
Teredo navalis.	Teredo navalis.
Jaw of a crocodile.	
Testudo, or Turtle.	
Various Fish, but too mutilated to ascertain the species.	
Fish teeth, supposed by some to belong to the shark.	
Molar teeth of fish, called Bufonites.	
Palatum Scopuli, and other palates of fish.	
Tongue of a fish of the genus Raia.	

NAMES GIVEN BY LAMARCK.	LINNÆAN NAMES.
Tail of the Sting Ray.	
Scales of fish.	
Vertebræ of various species of fish.	
Cancer, above 20 species of crabs.	
Gammarus, or lobster.	
Crangon, or prawn.	
Wood, often pierced by the Terredo navalis, and filled with pyrites or calcarious spar.	
Fruits, branches, excrescences, ligneous seed vessels, and berries impregnated with pyrites.	

These fossil remains very nearly resemble those found in the lower marine formation in the basin of Paris,—a point of agreement of great importance, as it leads us to the probable inference, that the lower marine formation of the south of England belongs to the same deposite. This inference is strengthened, when we compare together the minerals of the different beds in the English and French formations.

Thus the plastic clay in the Paris basin agrees in most of its external characters with that found in the Isle of Wight and London basins; and further, both agree in the purer clays being destitute of organic remains, whilst the upper contains fossil cythera and turritellæ. A species of coal also occurs in the lower strata of the Paris

basin, and appears to be analogous to that found in a similar situation in the Isle of Wight basin; and the French sands agree in characters with those found in the Isle of Wight basin.

In the English basins there occur but few rocks that can be identified with the coarse marine limestone of the Paris basin. The rocks of Bognor appear to be the most easily referable to some of the beds of the coarse limestone of France; yet, in the Paris formation, there is no single rock possessing the same external characters as those exhibited by the London clay. But the London clay contains the same petrifactions as the coarse limestone; and if we could suppose a blending or mixture between the French plastic clay, which is blackish, and contains organic bodies, and the lower beds of the coarse limestone with its green earth and petrifactions, we should have a compound agreeing sufficiently near with the London clay under all its varieties; with this difference, that that of the French basin would have a greater proportion of the calcarious, and of ours of argillaceous matter. But with respect to the upper beds of the coarse limestone of France, no strata have as yet been discovered in England that correspond to them.*

2. *Lower Fresh Water Formation.*

It consists of a series of beds of sandy, calcarious, and argillaceous marls. Some of them appear to consist almost wholly of the fragments of fresh water shells, viz. lymenus, planorbis, cyclostoma, and others resembling helices, and mytuli. In its lower part it alternates with beds containing marine remains. This formation occurs in the Isle of Wight, but not in the London basin.

* Webster's Geological Transactions, vol. ii. p. 209.

According to Mr. Webster, it is in this formation, in the Paris basin, that the gypsum beds are situated.

3. *Upper Marine Formation.*

Over the lower fresh water formation in the Isle of Wight, a stratum occurs, consisting of clay and marl, which contains a vast number of fossil shells wholly marine. Ten of the species agree with those found in the London clay, but they differ from them in their state of preservation. Most of them appear to have undergone but little change, and some of the species are even scarcely to be distinguished from recent shells.

Delicate marine shells, in a state of perfect preservation, occur in some parts; thus showing that they could not have been brought from great distances, but must have lived near to the spots where they are now found. In other beds we meet with banks of large fossil oyster shells, the greater part of which are locked into each other in the way in which they usually live, and many have their valves united. It is therefore evident, that these oysters had not been removed from a distance to their present situation.

If we depend upon petrifactions as one of the means of enabling us to discriminate the different flœtz strata, we shall see reason to believe, that the last of the marine depositions in the south of England are nearly allied to the upper marine formation in the basin of Paris.

In this bed in the Isle of Wight, Mr. Webster found the following petrifactions:

NAMES GIVEN BY LAMARCK.	LINNÆAN NAMES.
Cerithium plicatum.	Murices.
lapidum.	
mutabile.	
semicoronatum.	
cinctum.	
turritellatum.	
tricarinatum.	
Cyclas deltoidea.	Venus.
Cytherea scutellaria.	Venus.
Ancilla buccinoides.	Voluta.
subulata.	Voluta.
Ampullaria spirita.	Helices.
depressa?	
Murex reticulatus.	
Bivalve, apparently of the genus Erycina.	
Helicina?	
Murex nodularius.	
Melania?	
Natica Canrena.	
Ostrea, approaching to deltoidea.	
——— specific characters not evident, but different from the last.	

In the same formations at Harwich, in Essex, the following petrifactions occur:

NAMES GIVEN BY LAMARCK.	LINNÆAN NAMES.
	Patella ungaria.
	lævis.
Patella spirorostris.	fusca.

NAMES GIVEN BY LAMARCK.	LINNÆAN NAMES.
Fissurella labiata.	
emarginula.	fissura.
Calyptrea sinensis.	Patella sinensis.
Eburna glabatra.	Buccinum glabratum.
	Murex corneus.
	erinaceus.
	contrarius.
	Trochus sulcatus.
	alligatus.
Ampullaria rugosa.	
Natica canrena.	
glaucina.	
Mactra.	
Venericardia senilis.	Arca senilis.
Lucina.	Venus galina.
	Solen siliqua.
Pholas crispata.	
	Ostrea deformis.
Pecten plebeius.	
infirmatus.	
Balanus.	

Some of these, however, may belong to the lower marine clay.

Mr. Webster appears to consider the Bagshot sand, which extends over a considerable tract of country in Surrey, and the blocks of granular quartz, named *gray weathers*, met with in Berkshire and Wiltshire, as members of this formation, and somewhat allied to the sand and sandstone of the upper marine formation in the Paris basin.

4. Upper Fresh Water Formation.

This formation also occurs in the Isle of Wight, in the hill of Headen, where it rests immediately on the last mentioned, or upper marine formation. It is an extensive calcarious bed, fifty-five feet in thickness, every part of which contains fresh water shells in great abundance, without any admixture whatever of marine organic remains. The marl is soft, and easily affected by the weather, but includes a harder variety, which is so durable as to be employed as a building stone. Many of the shells found in this bed are quite entire, and these are intermixed with numerous fragments of the same species. They consist, like the lower fresh water formation, of several kinds of lymnei, helices, and planorbes; and from the perfect state of preservation in which they are found, appear to have lived in the places where they now are, the shells of these animals being so friable, that they could not have admitted of removal from their native situations without being broken.

Over this bed is another of clay, eleven feet in thickness, containing numerous fragments of a small non-descript bivalve shell. Upon this lies another bed of yellow clay without shells, and then a bed of friable calcarious sandstone, also without shells. To this sandstone succeed other calcarious strata, containing a few fresh water shells. In these are parts of extreme compactness, and other parts contain masses of a loose chalky matter, most of which are of a round form; and among these also are many beds of a calcarious matter, extremely dense, and much resembling those incrustations that have been formed by deposition from water on the walls of ancient buildings in Italy. Through all these last strata are veins, frequently several inches in thickness, of ra-

diated calcarious spar. It contains the following fossil shells:

Planorbis, much resembling that which Brongniart says approaches to P. cornu.
Planorbis, two other species.
Planorbis, much resembling P. prevostinus.
Ampullaria.
Cyclostoma.
Limneus longiscatus.
— acuminatus.
— corneus.
Gyrogonites is the petrified seed of a species of chara.

This formation is the latest of the flœtz rocks hitherto observed in this island, and it agrees nearly with its corresponding formation in the Paris basin, with this difference, however, that it contains no siliceous beds.

5. *Alluvial Formations.*

The flœtz rocks already described, are in many places covered with various alluvial deposites. In the Isle of Wight and London basins, the alluvium, besides the vegetable earth, clays, marls and sands, contains a vast quantity of rounded quartose pebbles, of various kinds and sizes, which are irregularly distributed, in some places forming thick beds, mixed with clay, sand, and small fragments of flints; in others are mixed with shells of various kinds, and sometimes almost without any other substance. This compound is named *Flint Gravel.**

* Some of these pebbles are evidently fragments of the flint originally belonging to the chalk formation; but other varieties are of calcedony and hornstone. Another remarkable class of siliceous pebbles is

The alluvial deposites in the south of England also contain fossil bones of quadrupeds; and these, according to Mr. Webster, are of different dates.* The most ancient are entirely petrified, and where found in gravel, are conjectured to have been washed out of the strata in which they were originally imbedded. Of this kind are probably remains of the mastodon, mentioned by Mr. Parkinson. The next class contains the bones of the elephant, rhinoceros, hippopotamus, and the Irish elk, which are frequently accompanied with marl, and fresh water shells. They are, however, not petrified; and though generally in a state of decay, yet are sometimes quite perfect. They are particularly abundant in Suffolk and Norfolk, but have also been found at Brentford, in

---

found either mixed with the flints, calcedonies, and hornstones, or alone, or cemented into a pudding stone. These, according to Mr. Webster, appear to have been originally formed of concentric coats, or layers of different colours, which vary in almost every specimen. The colours are for the most part yellow, brown, red, bluish, black, gray, and white; but these run into each other by an infinite number of shades. Others are spotted, or clouded with different tints, and have much the appearance of Egyptian pebbles. They take an excellent polish, and are then often extremely beautiful. These last appear rather more to resemble agates than chalk flints. They are never found of large size, seldom exceeding two inches in diameter, and generally are not more than one inch. They are of an oval or flattened form, which appears to have been their original figure, although they have evidently been subjected to a certain degree of attrition. The well known pudding stone of Hertfordshire is composed of these concentric pebbles, imbedded in a basis of granular quartz. These concentric pebbles, like the imbedded masses of flint in chalk, of agate in trap, and of felspar in porphyry, are to be viewed as having been formed at the same time with the rock in which they were formerly included.

* It is still uncertain whether or not all the substances named alluvial, are strictly of this nature. The geognostic relations of many alluvial alleged deposites are still but imperfectly known.

the Isle of Sheppey, and several other places. Other bones of ruminating animals, as those of the horse, ox, and stag, not different from the living species, are frequently dug up at small depths, and are covered by peat, gravel, loam, &c. Similar organic remains occur in the alluvial strata, over the new flœtz rocks around Paris.

The following tabular view of the upper formations in the southeast of England, will convey to the reader a distinct conception of the new formations just enumerated, and also of several of those immediately below them.*

1. *Alluvial.*

The debris of previously existing strata, formed either by the present existing causes, or by others that have acted at an early period. The substances are principally water-worn fragments of flints, mixed with sand and clay in various proportions.

2. *Upper Fresh Water Formation.*

This, in the Isle of Wight, consists of a limestone containing numerous imbedded fresh water shells. It agrees in several of its characters with the corresponding formation in the basin of Paris, and other parts of the continent of Europe. Traces of a fresh water formation are also to be observed in the London basin, between the alluvium and the London clay, consisting of marl with fresh water shells, and containing also numerous bones of land animals, as the elephant, hippopotamus, buffalo, elk, ox, &c. These have been chiefly found at Sheppey, Brentford, Essex, Suffolk, and Nor-

* See Webster, in Sir H. Englefield's interesting and valuable work on the Isle of Wight.

folk. In other places, as at Sheppey, Emsworth in Sussex, &c. vast quantities of the fruits of tropical countries have been found in a corresponding situation.

3. *Upper Marine Formation.*

This bed consists of bluish or greenish marl and clay, containing a great number of fossil marine shells, which, in general, are different from those found in the London clay. It is known in this country, with certainty, only in the Isle of Wight.

4. *Lower Fresh Water Formation.*

This formation is ascertained in the Isle of Wight. It is placed under the last, and consists of clay, marl, and sand, with vegetable matter resembling an imperfect coal, or peat, and contains numerous fragments of fresh water shells. At the bottom is formed a mixture of marine with fresh water shells. As the alternation of marine with fresh water strata has not been observed in any other part of this country, except the Isle of Wight, the traces of a fresh water formation in the London basin cannot perhaps be referred to this.

5. *Sand without Shells.*

In the Isle of Wight this sand is extremely pure; it is dug at Alum Bay, and is used for making the best glass. The Bagshot Sand, perhaps, belongs to this; and possibly the Grayweathers; but the position of these has not yet been accurately determined.

6. *London Clay.*

This is the blue clay of London, Highgate, Sheppey, Portsmouth, Stubbington, Hordwell, Southend, Harwich, &c. It is distinguished by its septaria, and its beautiful and numerous organic remains. In Alum Bay it is the

most northerly of the vertical strata. Bognor rocks are subordinate to this bed. It agrees in its petrifactions, and geognostic situation, with the lower beds of the coarse marine limestone of the Paris basin.

7. *Plastic Clay and Sand.*

The clay in this formation is often extremely pure, and fit for the potter. It is much employed in the potteries in Staffordshire. It is seen in Alum Bay, the trough of Poole, and at the bottom of the blue clay in many parts of the London basin. A kind of bituminous wood is sometimes found in it. This formation is conjectured to correspond to the French plastic clay, which lies over the chalk.

8. *Chalk with Flints.*

This formation is not known in Scotland, but in England extends from Flamborough Head, in Yorkshire, to a little beyond Lyme Regis to Devonshire; and where it is not covered with the newer flœtz rocks, forms the chalk-hills or downs. It is distinguished by the regular layers of flint nodules.

9. *Chalk without Flints.*

The inferior stratum of chalk in the southeast part of England is always without flints; when the chalk with flints is wanting, it forms the surface. The relations of both may be seen at the Culver, and Compton Bay, in the Isle of Wight, Handfast Point, Beachy-head, Guilford, Dorking, &c. It differs from the former principally in the absence of flints, in the beds being thicker, and the chalk being sometimes a little harder.

10. *Chalk Marl.*

This stratum consists of chalk and an intimate mixture

of clay; it is always found below the two last strata. It may be readily distinguished from chalk by its falling in pieces on being wetted and dried again. Some varieties of it, when burnt, form an excellent cement for building; it is also a valuable manure.

11. *Green Sandstone.*

This formation consists of siliceous earth united by calcarious matter; and contains also mica and green earth. From the variety in the proportion of the latter ingredient, it is by some divided into the green sand and gray sand, a distinction which cannot always be made, since these alternate and pass into each other. It is found in the wealds of Kent and Sussex, at the foot of the chalk downs; and is dug at Rygate and Measham for freestone. It is seen also at Folkstone, Beachy-head, the Culver and Compton Bay, in the Isle of Wight, Pewsey, in Wiltshire, &c. Alternating with it are often beds of limestone, as at Maidstone, in Kent, where they are called Kentish Rag; also in the Undercliff, Isle of Wight, beds of hornstone occur in it. It abounds in organic remains.

12. *Blue Marl.*

This bed may be seen under the former very distinctly in the Isle of Wight; as at Sandown Bay, many parts of the Undercliff, Niton, and Compton. It contains very few petrifactions.

13. *Ferruginous Sand.*

This formation consists of an alternation of quartzy sandstone, clay, and limestone. The sandstone contains always more or less oxide of iron, sometimes in such quantity, as in the wealds of Kent and Sussex, that it was formerly employed as an ore of iron. The clay tracts of

the wealds belong to it. This formation may be also seen at Sandown Bay, Blackgang, and Compton Chines, Swanwich Bay, Hastings, Tunbridge Wells, &c. Fossil shells are rarely found in it; but brown coal is met with frequently.

14. *Purbeck Shell Limestone.*

This formation consists of numerous beds of shells and fragments of shells, cemented together by calcarious spar, and alternating with shell and marl. The Purbeck, and perhaps the Petworth marbles, form part of the series; and it is further remarkable for containing numerous fresh water shells and bones of the turtle; hence it is conjectured to have been formed from fresh water.

15. *Clay with Gypsum.*

At Swanwich, in Dorsetshire, this is dug under the shell limestone. The gypsum does not occur in great quantity, but is employed for plaister.

16. *Portland Oolite.*

This includes the stone of Tillywhim and Windspit quarries in the Isle of Wight, called Purbeck Portland, and that from Portland Island. It is entirely calcarious, and is formed of small grains or concretions adhering together. It is the only stone used for the fronts of public buildings in London. Some of its beds contain many marine shells; also fossil wood and hornstone.

17. *Bituminous Shale, containing the Kimmeridge Coal.*

This formation may be seen at Kimmeridge, Encombe, and the Isle of Portland.

The discoveries of Cuvier, Brongniart, and Webster, of which we have now given a pretty full account, have

added a most interesting and curious set of rocks to the geognostic system. They have connected, more nearly than heretofore, the alluvial with the flœtz formations, and have thus rendered more complete the series of rocks which extends from granite to gravel. Not the least interesting of the consequences resulting from the discoveries of these Naturalists, is the extension they give to our views in regard to the former nature of the animal world, and of the changes it has experienced during the different periods of the earth's formation.

The following extract of a letter addressed to me by Mr. Marsden, the author of the well known and excellent Account of Summatra, ought to have been inserted in another part of the work, but was until this moment mislaid.

"In your instructive Notes to the Translation of M. Cuvier's Essay on the Theory of the Earth, you observe, that I appear to have misunderstood that able naturalist, when I say that he accuses me of confounding the hippopotamus with the dugong. You will not, I am persuaded, think me unreasonably pertinacious, when I take the liberty of pointing out to you the passage in M. Cuvier's writings that drew from me the remark (in the last edition of the Summatra) which you have done me the honour of quoting, and which you will find to be quite distinct from that where he supposes that I may have confounded with the former the *succotyro* of Niewhoff. This supposition, indeed, I should not have thought of controverting, as the animals, if not in fact the same, have a general resemblance to each other, and I do not myself make pretension to any critical knowledge in zoology; but with respect to the dugong (or *duyong*) the matter was different, and it became necessary to vindicate myself from the charge of so palpable a mistake.

"Le nom de vache marine (says M. Cuvier, Annales du Museum d'Histoire Naturelle. Tome treizième. Sur

l'Osteologie du Lamantin, par G. Cuvier. p. 302.) ayant été donné par les Hollandois et par quelques autres peuples, à l'hippopotame, aussi bien qu'au *dugong*, certains voyageurs, trompés par cette homonyme, ont placé des hippopotames dans quelques pays où ils avoient entendu dire qu'il y avoient des *vaches marines*, tandis qu'on ne vouloit leur parler que de *dugongs*. J'ai une preuve récente de ce méprise. Un voyageur très-instruit me soutenoit avoir apporté des dents d'hippopotames des Molluques; quand il me les montra, je vis que c'étoient des dents de *dugong;* et je suis maintenant fort porté à croire que c'est de cette manière que Marsden aura cru *pouvoir* donner des hippopotames à l'île de Sumatra."

"I certainly was guilty of an omission in referring my readers only to one of the passages in M. Cuvier's writings in which my name was introduced, and not to that which would have been the most to my purpose. With regard to the consistency of the two, I shall only say that there appears something like a desire of supporting an hypothesis at any rate.

"Perhaps in a future edition of your Book (which will, I have not a doubt, be immediately called for) you may think it right to notice briefly, that I had stronger grounds for my remark than were at first apparent, and that I had not misunderstood the particular passage to which it had reference. At all events, I feel a satisfaction in setting myself right, as I trust I do, in your opinion, as well as in the opportunity it gives me of subscribing myself, with much esteem,

Dear Sir,

Your faithful

Humble Servant,

W. Marsden."

OBSERVATIONS

ON THE

GEOLOGY OF NORTH AMERICA;

ILLUSTRATED

BY THE DESCRIPTION OF VARIOUS ORGANIC REMAINS FOUND IN THAT PART OF THE WORLD.

BY SAMUEL L. MITCHILL,

Botan. Mineral. et Zoolog. in Univers. Nov. Eborac. Prof. &c. &c.

INTRODUCTION.

THE spirited disposition repeatedly manifested by the publishers, has induced me to furnish an article for their New-York impression of Professor Jameson's edition of the Chevalier Cuvier's Theory of the Earth. A work composed under peculiar advantages by a happy genius in France, comes to us, recommended and improved by the talents of a leading naturalist in Scotland. I should be proud to accompany those illustrious men on a tour through the United States.

For myself, it becomes to state some of the opportunities, which have prepared me for so serious an undertaking.

While I resided in Paris, I endeavoured to acquire as much information as possible from the admirable institutions there. But, the present constellation of science, had not then risen.

During several visits to London I became an industrious visiter to the museums, libraries, galleries, and even

the environs of the city. The rapid and increasing march of knowledge, since I was there, has outdone all former example.

My continuance in Edinburgh, enabled me to study under able masters. My tours around that great seat of learning, and an excursion to the mountains, rendered me more than an admirer of natural scenes in perspective. I was taught to penetrate beyond the surface, and to conceive something of geognostic formation. Now, however, the light of science shines wider, and deeper, and brighter ; and enables her favourite labourers, more than ever, to share the benefit of its rays.

On my return to North America, I found my fellow citizens of New-York occupied in a negotiation with the Five Indian Nations, for the purchase of their land, situated to the westward of Fort Schuyler, and extending away to Lakes Ontario and Erie. I became convinced, on attending that important treaty in 1788, that a proper acquaintance with the productions within its limits and along its confines would add most important materials to natural history. After all that the travellers and observers had done, from Father Hennepin to John Bartram and Lewis Evans, there appeared to be a boundless field for investigation.

I had an opportunity to make further observations when, in 1796, I performed an excursion at the request of the Society for the Promotion of Agriculture, Arts and Manufactures, for the purpose of exploring the region near the banks of the Hudson river and its tributary streams, for minerals. I made a report on the several tracts of country I had visited. These I divided into, 1. the Granitical ; 2. The Shistic ; 3. The Sand-stone ; 4. The Lime-

stone, and 5. The Alluvial. This was published in the Transactions of that excellent Society, and in the first and third volumes of the Medical Repository. Mr. Volney, who has written the best account of the mountainous chains and atmospheric currents in the United States, did me the honour to quote my performance with respect.

Since that time, tours to Lower Canada and Quebec, to Niagara and the adjacent part of Upper Canada, and to Virginia, have contributed to increase my knowledge; as have also several journeys by land and a voyage by water, to explore Long-Island and the rocks, islands and shoals in its vicinity. My information too has been exceedingly increased by the intercourse with sensible men, and by the acquisition of fossil specimens.

On a survey of the whole ground, it appeared to me there was room for a geological classification in a four-fold order; thus,—

1. The most ancient foundation of the globe.
2. The depositions from inland seas or reservoirs of salt water.
3. The depositions from fresh water.
4. Modern depositions from the briny ocean.

During this period, individuals in several places began to form mineral collections, and to travel for the *sake of procuring* information and specimens.

In a particular manner, William Maclure, Esq. took a broad survey of the Fredonian States, and delineated upon a chart the several geological regions according to the system of Professor Werner. He composed a memoir, in explanation of his map, which is

rich in original and scientific intelligence. This performance is the more valuable, inasmuch as the able and discerning author went extensively over the country and examined its geognostic condition with his own eyes. He had the satisfaction of seeing them published in the Transactions of the American Philosophical Society. He afterwards laid them before the learned world, in French at Paris. And he has, very lately, published a new and improved edition in the United States. I agree with that gentleman (p. 26.) in his Observations on the Geology of the United States, &c. that "the shells and other remains of organized matter, have not been examined with that accuracy necessary to form just conclusions. The notice he takes of such reliquiæ in p. 27. 54, 55, and other parts of his work, show the importance he attaches to them.

Among the early promoters of mineralogical inquiry, Archibald Bruce, M. D. deserves to be remembered. The four numbers of his Mineralogical Journal, contain so much new and interesting matter, that a sentiment of universal regret prevails on account of its discontinuance. His lectures and his museum prove his successful exertions.

Mineralogy owes much to the enterprising spirit of Col. George Gibbs. By a happy concurrence of fortune with inclination, this gentleman has enriched his country with extensive and splendid collections from transatlantic countries. While New-Haven extols his munificence, his friends in New-York have received his promise that something worthy of himself and of the science, should be done for their institution. His example has gained him fame and followers. It is charming to observe in the young gentlemen who have studied at Yale College,

the intellectual heat and light which, like the collision of flint and steel, his grand cabinet has excited in their minds.

Professor Cleaveland has done a full proportion toward the advancement of mineralogical and geological science. His late publication is a manual of instruction for all who are disposed to learn. In the compilation, he has described the modern method as it ought to be; he has been liberal to his cotemporaries, and just to his country.

Much commendation is due to John G. Bogert, Esq. who has evinced a most commendable and successful zeal both in the collection of specimens, and in the generous use he makes of them. He deserves to be ranked among the first friends and ablest promoters of this kind of knowledge.

His Excellency Dewitt Clinton has contributed greatly toward the promotion of this as well as other sciences. A lover alike of sound learning and of those who excel in it, he has proved himself both an admirer and a proficient. By exertions of his own and of the meritorious men he has patronized, he has accumulated a body of important facts and intelligence. He has proved himself as capable of philosophizing as of collecting. By the brightness of his lamp, his neighbour sees no less comfortably than himself.

Many gentlemen might be mentioned, for the aid they have afforded to this branch of science, such as Schaeffer, Steinhauer, Haines, Griscom, Akerly, Silliman, Cooper, Beck, Conrad, Low, Seybert, Mease, Godon, Wetherall, Collins, Nuttal, Bradbury, and more than I can enumerate at this time. Suffice it to observe, that with-

in a few years, the attention of our citizens has been turned to the pursuit of geology and mineralogy with an interest and success never known before. It is in consequence of the information brought home by tourists and travellers, and that which I have collected during many trips and excursions of my own, that I was enabled to compose a memoir on the organic remains of the region around New-York, and read the same to the Literary and Philosophical Society. In that paper I described upwards of twenty animals which I presumed to be extinct, because there were no living vestiges of them known.

Many new facts have been disclosed since that time. I am satisfied that New-York is as important a centre of geological productions and occurrences, as London, Paris, or Rome. Under this persuasion, I have consented to add a brief memorandum concerning American fossils, and some of the geognostic features of those districts where they lie. It may serve as an outline of the great work, now just begun, and perhaps as a direction to the inquiries of those who shall engage in these or similar investigations.

GEOLOGICAL OBSERVATIONS, &c.

The Original Saltness of the North American Lakes.

THE remains of marine animals in the soil and rocks adjacent to the lakes, may be cited as proofs that the ocean once filled the basins of the latter and covered the surface of the former. Lithophytous and testaceous relicks are so plain and numerous, that it is impossible to resist the evidence. Organic remains abound in the greater part of the distance from lake Erie through the counties of Niagara, Genesee, Ontario, Seneca, Cayuga, and Onondaga. They exist plentifully too in the counties of Lewis, Jefferson, St. Lawrence, Madison, Essex, Oneida, Montgomery, Washington, Chenango, and various others.

At the remarkable sulphureous spring in the town of Phelps, eleven miles northwest of Geneva, they appear like corallines and madrepores. On both sides of the Genesee and Tonewanto rivers, they resemble marine shells. While on the east and west banks of Niagara river, they assume, in addition to the already enumerated forms, those that have erroneously been called petrified wasps' nests and honey-combs. They are hereabout mostly bedded in fetid limestone. Sometimes they are blended with

pyrites. In others they are penetrated by the petroleum called Seneca-oil.

On viewing these productions, the mind endeavours to fix that unascertained time when the oceanic water of the primitive globe rolled over this region; how the dams and barriers which restrained the floods gave way and laid bare the land; and wherefore the receptacles of water were shrunk and narrowed to their present size. The saline waters were thus collected into lakes, and pools, diversifying the interior regions of this continent with a remarkable mixture of land and water.

It may be rationally concluded that the internal seas, now called lakes, were originally filled with salt water. Their present freshness is the consequence of the dilution they have gradually undergone, changing them from briny to fresh water.

To understand this subject, let Ontario, Erie, Huron, Michigan, and their dependencies, with the upper lakes, be compared with the collections of salt water in the other parts of the world.

The Caspian is naturally salt, and retains that quality because there is no outlet. The waters it receives by the rivers and rains are so nearly balanced by that which goes off by evaporation, that this grand reservoir has never burst its boundary.

The like observation applies to the Dead Sea in Syria. The exhalation from its surface seems to be supplied from the influx of the Jordan; and there has been no sufficient accumulation to force a passage out.

The Mexican lakes present a case which strongly corroborates this doctrine. Of the two lakes which impart health and convenience to the city of Mexico, the upper one is fresh, the lower salt. This salt is not a muriate, but a carbonate of soda, like that in the nitrian ponds of Egypt. The two streams which feed the upper lake, have changed both the mass and character of the water. The salt has been washed out, and carried down to the lower lake. There it stagnates, until it escapes, by evaporation, or through the expensive aqueducts constructed by the government. The rise of the water in the lower basin frequently overflows an extensive surface of low land, and sometimes inundates the contiguous part of the city. When it dries up and leaves bare the surface, an alkali is often left, which the inhabitants gather and sell to manufacturers of soap.

The Mediterranean has a communication with the Atlantic, and its saltness is supported by the great supplies it receives through the Herculean straits near Gibraltar.

The same remark may be made concerning the Black Sea, or Euxine. It seems to be now understood, particularly since the publication of Mr. Ingigian's History of the Thracian Bosphorus, that the level of the Marmora and the Euxine is so nearly the same, that the current sometimes runs through the canal of Constantinople, as some call it, northeastwardly to replenish the Euxine, and then again, southwestwardly to evacuate it. When, therefore, the supplies from the Danube, the Dnieper, the Dniester, the Don, the Kuban, the Phasis, and other streams, fail to raise the Euxine high enough to force into the Marmora and the Ægean, there is still water, both heights being the same. If the Black Sea heightens from new accessions of water, the outward current runs. But

whenever the Mediterranean becomes more elevated, or the Ægean or Marmora seas are higher than the Euxine, the current proceeds the other way, and a flood of salt water pours into the Euxine, until the level is restored. This flux and reflux, this current and counter-current, explains a fact mentioned by the elaborate Le Sage, that the Euxine is not so saline as the ocean; though, as Professor Clarke relates, briny enough at the Crimea, to enable salt to be manufactured. Thus the Euxine receives salt water from the Mediterranean as occasion may require. In theorizing upon its saltness, it may be considered as less saline than it originally was. It may be expected to grow fresher, by slow degrees, until, possibly, after a very long course of ages, the Black Sea may become as fresh as lake Superior.

The inland seas of North America differ from all these cases, except that of the upper lake of Mexico. They are unlike the Caspian and the Judean seas, because these latter have no outlets. They vary from the Mediterranean and Euxine, inasmuch as the supplies of the latter are abundant; and the outlets of the American lakes pass along such declivities, and are so rapid and precipitous, that the stream always sets one way, and a reflux is impossible. If the American lakes had originally been ink or alcohol, instead of brine, the respective fluids would have long ago, by incessant supplies of pure water, passed through all the stages of dilution, and have wholly lost their coloured or spirituous qualities. Their original saltness may therefore be conceived as having been incessantly weakened by the copious and incessant supplies of fresh water; and the freshened water which descended the rapids and the cataracts, fell to a depth whence it was impossible for it to flow back.

Under such circumstances, where the salt water was continually going forth, and the fresh water occupying its place, it must necessarily have happened that the former would gradually be exhausted, and its place occupied by the latter. Thus it may be conceived that the primitive saltness of our lakes was lost.

When, however, we survey the oceanic relicks on their shores, prodigiously diversified in number, quality and form, we cannot refuse full credit to the conclusion.

And when we also reflect, that Erie and its continuous lakes, Huron and Michigan, abound with animals, which probably once inhabited salt water, we are led to consider the interesting process, whereby, during the freshening of the water, they were weaned from their marine habits, and gradually converted to fresh water animals.

The Cod of the Lakes, (gadus lacustris) forwarded to me from Massachusetts, by Henry A. S. Dearborn, Esq. of Boston; and the *Salmon without teeth* (salmo clupeoides) brought to me from the falls of St. Mary, by Major Roberdeau, are creatures of this description.

The Barriers which probably restrained the Waters, in some parts of North America, after the Ancient Ocean had retired.

If we examine the face of the country, we shall probably discover the remains of the old dams or barriers by which the waters were restrained, for a considerable time after the ocean had subsided.

I. THE INNER OR UPPER BARRIER.

One of these seems to have circumscribed to a certain degree the waters of the original lake Ontario. It is reported to be distinguishable on a mountainous ridge beyond the river St. Lawrence, in Upper Canada, and situated northeast of Kingston. Passing thence into the state of New-York, it may be traced as it divides the streams which empty into the present lake from those which discharge into the river St. Lawrence. It thus separates the Black River from the Oswegatche. Passing along, it parts the head waters of the Hudson from the La Grasse, the Racket and St. Regis, which run in the opposite direction, or northward. This elevation or mound appears to have been continued to the north end of lake George, and to have formed the mountainous ridge on the east side of that lake. It apparently travelled along, crossing the Hudson above Hadley Falls; and passing to the southward of Sacondago, crossed the Mohawk at the Little Falls.

There can be no reasonable doubt that a more correct and minute survey will delineate the continuation of this mound, or of its ruins, toward the eastern sources of the Susquehannah, and particularly the branch called Char-

lotte river, dividing them from the Canajoharie and the Schoharie, two streams which fall into the Mohawk from its southern side. Geologists will follow it along as it parts the Cookwago and Papachton branches of the Delaware river, from the Plattekill, Esopuskill, and Rondeoutkill, which empty into the Hudson. I entertain no doubt the entire or broken chain will be found which made the junction with the Great Shawangunk, near the confines of Marbletown, Rochester, and Paltz, in the county of Ulster. Thence, or from the point where the Rondeout joins the Wallkill, the Shawangunk mountain raises and continues its immoveable mound in a southwesterly direction, through the northwestern part of New-Jersey. It crosses the Delaware river a little to the northward of Easton; and leaving Nazareth and Bethlehem to the southeast, crosses the river Lehigh to the northward of Heidelburg, and the Schuylkill to the northward of Hamburgh, in Pennsylvania.

The dam of mountains is thence continued along to the north of Harrisburgh, over the Susquehannah, and so in a southwesterly direction, until it enters Maryland, and passes the Potomac into Virginia, at Harper's Ferry, immediately at the junction of the Shenandoah with that river.

In Virginia it seems to be confounded with the Allegany mountain. As far as I can trace them, by map, and by verbal information, the two grand ridges approach and perhaps coalesce by some cross ridges.

But in pursuing this mound which confined the waters, the Cumberland mountain presents itself, dividing the Tennessee river from the Cumberland river, and showing its abrupt termination at the Ohio, between the spaces

where the two just-mentioned rivers unite with the Ohio.

From this point, the eye of the inquirer looks over a wide gap or long tract of prairie, towards the hills which skirt the Illinois river, and the mountains west of cape Girardeau, beyond the Mississippi, probably furnishing the only remaining vestiges of the ancient barrier.

This grand rampart has, in the course of ages, been broken through in several places. I shall mention the principal breaches that have oome to my knowledge.

1. The breach at the northeastern extremity of lake Ontario.

The thousand islands, and the whole of the scenery in their vicinity, bear witness of the mighty rush of waters which at some former period prostrated the opposing mound, and left them as scattered monuments of the ruin. This must have contributed to lower lake Ontario to the level of its outlet, or to its present bed. By this operation the water must have subsided about one hundred and sixty feet from the height of the ridge road between the Niagara and Genesee rivers, so beautifully described by Dr. Clinton.* All the country on both the Canadian and Fredonian sides must have been drained and left bare on the occasion, exposing to view the water-worn pebbles, the works of marine animals, their solid parts buried in the soil, their relicks bedded in the rocks, and the whole exhibition of organic remains formed in the bottom of such a sea as that was.

* Introductory Discourse before the New-York Literary and Philosophical Society, note G.

Great masses of primitive rocks from the demolished mound or dam, and vast quantities of sand, mud and gravel, were carried down the stream to form the curious mixture of primitive with alluvial materials in regions below.

2. The breach at the northern extremity of lake George.

It may be presumed that the pressure of water continued for ages, finally demolished the barrier near the outlet of lake George. The sea must have subsided to the level of the breach, and the lake been diminished to about its present size. A part of the geological configuration in that neighbourhood may be traced in all probability to this source.

3. The breach made by the Hudson at Hadley Falls.

On ascending the Hudson, the traveller finds the country, as he approaches the cataracts of the Hudson, called Glen's and Hadley's Falls, composed of alluvial materials, mingled with detached masses of primitive rocks removed from their stratified beds. The quantity of this loose matter is so great, as to cause the name of Sandy-Hill to be given to the place where it is most abundant. But on exploring the river a few miles above Sandy-Hill, the marks of violence and disruption present themselves. The beholder becomes satisfied whence the loose materials came which he surveyed on his approach. They consist of the fragments of the broken barrier and of the sandy alluvion forced down the stream when the dam gave way.

In this case the primitive fragments and the alluvial

deposites are found contiguous to another formation of shistous trap and fetid limestone, full of marine shells and madrepores.

4. The breach at the upper falls of the Mohawk.

I have several times visited this remarkable spot, and am convinced the rocks formed at some remote period a mound which opposed the progress of the water eastward. "As you approach the falls," says Governor Clinton, "the river becomes narrow and deep, and you pass through immense rocks, principally of granite, interspersed with limestone. In various places you observe profound excavations in the rocks, made by the agitation of pebbles in the fissures, and in some places the river is not more than twenty yards wide. As you approach the western extremity of the hills, you find them about half a mile distant from summit to summit, and at least three hundred feet high. The rocks are composed of granite, and many of them are thirty or forty feet thick; and the whole mountain extends at least half a mile from east to west. You see them piled on each other like Ossa on Pelion; and in other places huge fragments scattered about, indicating evidently a violent rupture of the waters through this place, as if they had been formerly dammed up and forced a passage; and in all directions you behold great rocks exhibiting rotundities, points and cavities, as if worn by the violence of the waves or hurled from their ancient positions."*

As is the consequence in such cases, the upper country wears the face of a drained tract, and the lower country

* Introductory Discourse before the New-York Literary and Philosophical Society, note G.

exhibits the traces of rounded primitive rocks, interspersed with alluvial deposites.

5. The breach by the Delaware through the mountains above Easton.

The Delaware river is turned out of its course by the continuation of the Shawangunk mountain, and travels along its northwestern side from Minissink to Knowlton; there it has opened a way, and in doing so, drawn the water from the soil above, and covered the lands below with a medley of rocks, pebbles and sand.

But before this opening was made, the mountain seems to have been disparted at another place, called the Wind-Gap, through which probably the water of the inland sea was partially and temporarily discharged.

The vastness of this dismemberment impresses every traveller with a sense of its present grandeur, and of the prodigious force necessary to rend the mountain from its summit to its base.

6. The breach by the Lehigh through the mountains.

To the northwest of Bethlehem, in Pennsylvania, the river Lehigh shows the opening it has made through the Blue Mountain, as it is there called; a passage which, like those already mentioned, the physical geographer and geologist will contemplate with interest. An operation which laid bare the region covered with water above, and overspread with alluvial wash and displaced and rounded nodules of rock the regions below, is worthy of particular notice.

7. The breach made by the waters of the river Schuylkill.

The two branches of the river Schuylkill have effected a similar disruption through the same chain, there denominated the Albany mountains.

It appears by the report of Cadwallader Evans, jun. President of the Schuylkill Navigation Company, made in 1817, that the whole fall in the river from the coal mines above the Blue ridge to tide water near Philadelphia, is about four hundred and eighty feet. Of this the ascent from tide water to Reading is ninety-eight feet; and to the coal beds beyond the mountains three hundred and eighty-two feet. The specimens of coal, and the topography of the country, by Charles Snowden, Esq. are very characteristic and instructive.

It is represented that the upper stream of the Swetara has in like manner penetrated the barrier.

8. The breach made by the Susquehannah.

Some distance to the southward of the junction of the Juniata river, the forceful Susquehannah, fraught with the rains not only of the midland district of Pennsylvania, but of a very extensive region in New-York, has triumphed over the mountain barrier, there termed the north mountain, which impeded its course to Chesapeake Bay. When geognostic researches shall be pushed as far as they deserve, the scientific world will be fully and circumstantially informed of the natural and physical appearances at this memorable spot.

Water drained from the higher region, and comminuted

sand with detached rocks carried to the lower, characterize as elsewhere this remarkable tract.

9. The breach by the Potomac through the Blue Ridge.

Much might be written on this disruption of the Blue Ridge, or South Mountain, as it has sometimes been called. The great agent was probably the united current of the Potomac and Shenandoah. The mountains have every appearance of having formerly opposed a formidable barrier to the accumulated water. Obstructed, as it were by a dam, a pond or lake must have been formed beyond them. Their height is estimated at about twelve hundred feet, or not quite so much. Mr. Volney has incorrectly traced them along to the Catskill mountains of New-York; whereas they really belong to the Shawangunk chain, which is quite distinct, both as to its situation and composition, from the Catskill: the former being composed of quartzy rocks and amygdaloid, and the latter of sandstone.

The sides and summits of the mountains near Harper's ferry are in summer clothed with green oaks. Chestnuts, maples, and planes are frequent before the eye. The lime tree, the tulip tree, the locust tree, and the willow tree, overspread the surface with their verdure. While the persimmon, the passiflora, the calycanthus, and the papaw, strike their roots through the sands of the shores and the crevices of the rocks.

The predominating rocks and stones dispersed over the parts of Virginia and Maryland, which lie on both sides of the Potomac between the tide waters of Georgetown and the Blue Ridge at Harper's ferry, are quartzy.

Masses of this siliceous material, possessing different shades of whiteness, are very frequent along the road, as you pass through Loudon county on the south, and through Montgomery and Frederick on the north side of the river.

Yet it must be observed, that the mixtures of quartz are various in this region. Where the Potomac penetrates the strata of rocks at the Little Falls above Georgetown, they assume the forms of granite, granitine, and micaceous shist. In some instances, quartz and schoerl are associated. In others mica and garnet are blended. Frequently quartz is found by itself; and then again mica is aggregated into enormous masses, forming the high banks and much of the bed of the river. Several other mixtures of these materials are found hereabout. The micaceous shist containing small garnets may be seen advantageously at the Chain Bridge, three miles above Georgetown. The operations necessary for making a passage over the Potomac, have exposed the strata in a manner that favours examination.

The great falls of this river, ten miles higher up the country, are formed chiefly of micaceous shistus. The quantities are exceedingly great, and compose the high perpendicular and overhanging sides of the stream, as well as its bed, and the rocky islands between its two banks. The interior locks of the canal made here by the Potomac Company for facilitating intercourse, are dug through strata of micaceous shist.

But the opening through the Blue Ridge at Harper's ferry is of a still different character. The gap reaches from its summit to its base, and exposes to the observer its internal consitution. It is in such places that the pe-

culiar composition of the strata can be examined to more advantage than under most other circumstances. The rocks may be referred by the modern geologist to the TRANSITION order. At the gap there is scarcely any mica to be seen; but the quartz is abundant. The structure of the mountain may be comprehended under the following mineralogical disposition. First, quartzy rocks by themselves, with very little admixture. Sometimes large and milk-white or snow-white masses make their appearance in other strata. Secondly, quartz blended with shist or slate. Both the materials are distinct, and they make coarse associations. The quartz is compact, granular, white, semi-transparent, cellular, ragged, and of various other qualities; but not often crystallized. The slate is of different hues, from pale to brown, greenish and black. Thirdly, quartz and hornblende. The material which I take to be hornblende, is of a brownish and frequently of a somewhat greenish hue, and mingled intimately throughout with the quartz. This composition appears to me to resemble, more nearly than any thing I recollect, the rocks at the upper falls of the Mohawk river. The hornblende is not known to be distinct, fibrous or crystalline. Fourthly, quartz and iron. Very commonly the quartz is coloured by a ferruginous tinge, and assumes therefrom a brown, reddish or rusty colour, and imparts the same to the other ingredients. Fifthly, quartz and feldspath; though this mixture occurred so rarely, that it is but barely worth the mentioning. Sixthly, quartz filling the veins and seams of all the other rocks, and giving them stripes or bands of clear white, and sometimes marking them with fantastic flourishes.

Such are the principal materials and their combinations at the Blue Ridge, where the waters penetrate it, on the territorial line of Maryland and Virginia. But the mo-

ment you leave the mountains skirting the Potomac and the Shenandoah on their eastern or atlantic side, the minerals are of a different character. Immediately at their bases, and at the banks of these respective rivers, the strata becomes shistose. The streams pass by islands, and roll over beds of slate. The strata lie, where they have not been deranged, at angles of from thirty-three to forty-five degrees from the horizon; and their dip or inclination, particularly in the channel of the Potomac, is from N. W. to S. E. Suddenly as you pass to the Virginia side, the slate rises with a rough, craggy, and picturesque front.

Between the margin of the water and the foot of this elevation, stand the shops where the muskets, pistols, and rifles are manufactured for the United States. At this commodious spot, the water for turning the wheels and giving force to the machinery is conducted through a canal or raceway about a mile in length. In several places, this passage has been dug through layers of slaty rock. A principal part of the stone-work consists of the same material; for although it does not split into forms fit for covering houses, it may be separated into slabs and flags fit for walls and floors. Here it is rare to behold any mixtures of quartz; yet small parcels may be found. No other mineral abounds. Slate prevails every where. The heights from which the traveller surveys the sublime and picturesque scenery hereabout are slate. In short, whether wells are opened for water, foundations for buildings, or graves for the dead, parcels of shistus are raised with the spade. And from the lowly channel to the pinnacle where the powder magazine stands, the solid body of the mountain is brittle shist. In some places the layers appear to have been disturbed; for some of them are cracked through perpendicularly:

some approach a horizontal direction, and others are jumbled into confused heaps. The removal of sand, gravel, and under-propping by rains, has in some instances left the rocks in odd shaped piles; and as these shall be further deprived of support, they will quit their present abodes, and rush precipitous to the valleys. The road travelled by Braddock towards the fatal plains of Monongahela in 1755, and the ground occupied by the provisional army under Pinckney in 1800, are underlaid by foundations of slate.

Yet, in less than two miles, as you proceed up the Potomac, limestone makes its appearance; and you meet with the like in travelling a few miles up the Shenandoah. I am informed that shistus and quartz were heaped high in alternate and distinct strata, about ten miles hence, on the banks of this latter river.

Indeed it seems to me, as evident as the nature of the case admits, that in Virginia as in New-York, slate underlays and supports the limestone. And it may be conceived as in the highest degree probable, that the same material which reaches to the foot of the Blue Mountains, on the Virginia side of the Potomac, and on the Winchester side of the Shenandoah, is continued beneath their elevated ridges, and bears them on its back, as it does the Catskill and the Newburgh mountains in New-York. Let the geologists, in these parts of America particularly, study the history of slate.

The scenery about Harper's ferry is much and justly celebrated. Several artists have attempted to paint it. I recollect to have seen, several years ago, a picture of it, by some person whose name I do not now remember, in the Washington house at Mount Vernon. My atten-

tion was called to a striking view of it, at the principal inn near Ellicott's mills, on the Patapsco, in Maryland; and I examined an excellent sketch of the same, in the possession of a gentleman at Baltimore. The best spot for observation is a romantic pile of shistic rocks, situated between the summit and the Shenandoah. The prospect is eastward or down the stream. The two rivers unite at a point just beneath you, and pursue a roaring and foaming course through the dreadful breach they have made. The landscape consists of water finding its way toward the ocean amidst ledges and projections of rocks; of vegetables endeavouring to cover with their verdure the sandy beach, and the ruinous terminations of the strata; and of the ferries, roads, and buildings superadded by the industry of man. The whole is terminated by a distant perspective through the gap as far as the eye can distinguish, of woods, hills, farms, and other rural objects. The whole forms a rare and admirable display of the productions of art and of nature.

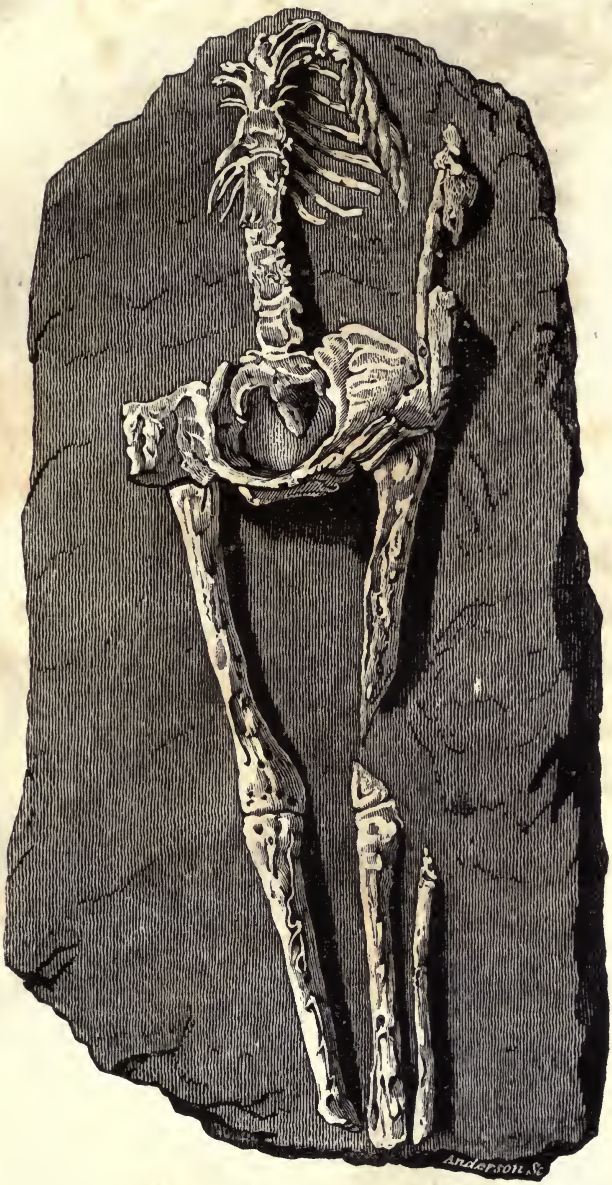
10. The breach made by James' river.

The valley situated on the head waters of James' river has apparently undergone a similar evacuation, and the lower country extending to Manchester, Richmond, and beyond, has been subjected to a corresponding change by the gush and inundation.

11. The breach the widest of all, between the Cumberland mountain and the hills at or near cape Girardeau, beyond the Missisippi.

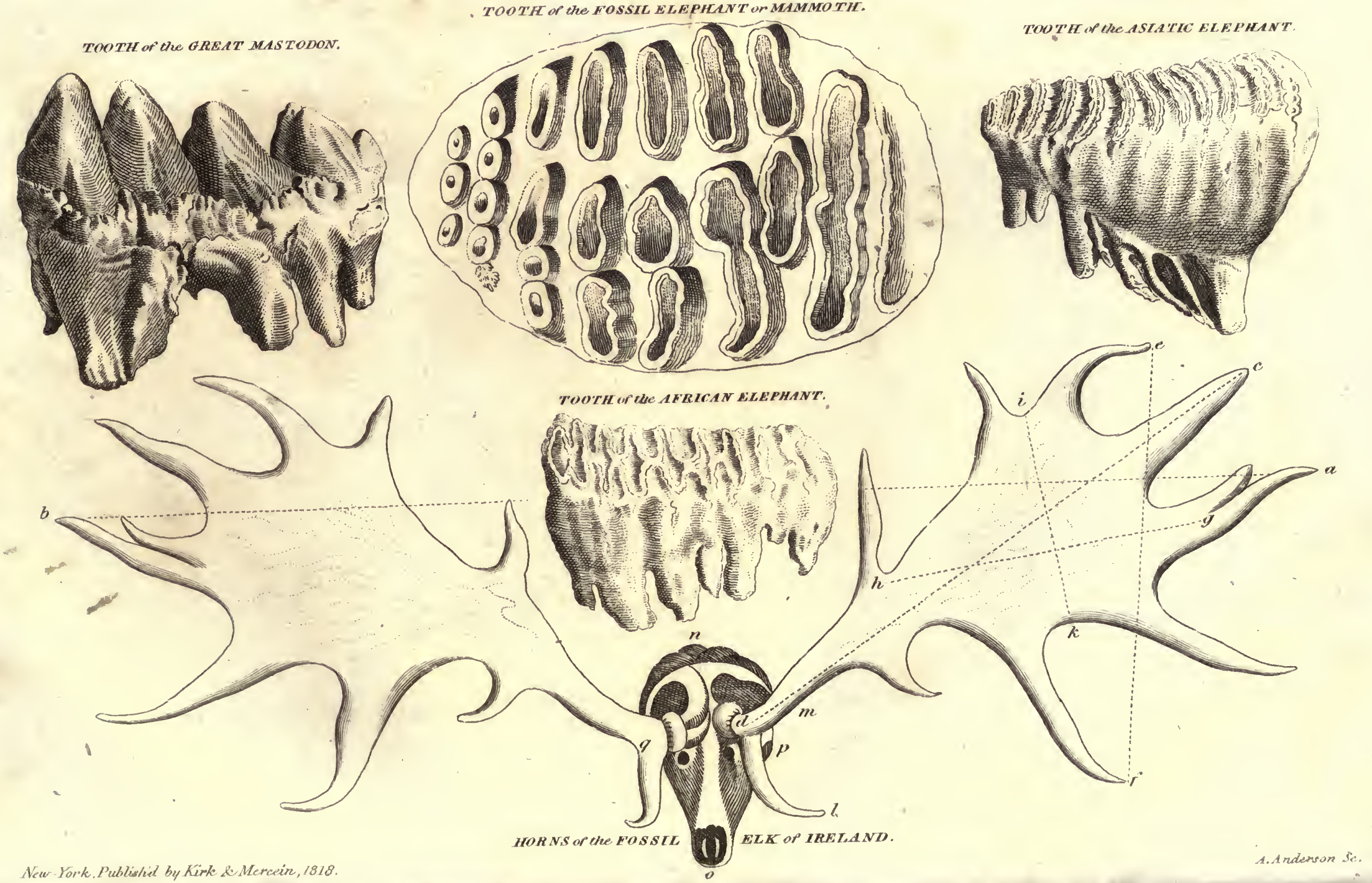
Over this wide tract, the barrier was either high enough to enclose the waters, or it has yielded to their impulse, over a broader space than in any other. It

PLATE I.



Fossil HUMAN SKELETON, found at Guadaloupe.

PLATE II.



New-York. Publish'd by Kirk & Mercein, 1818.

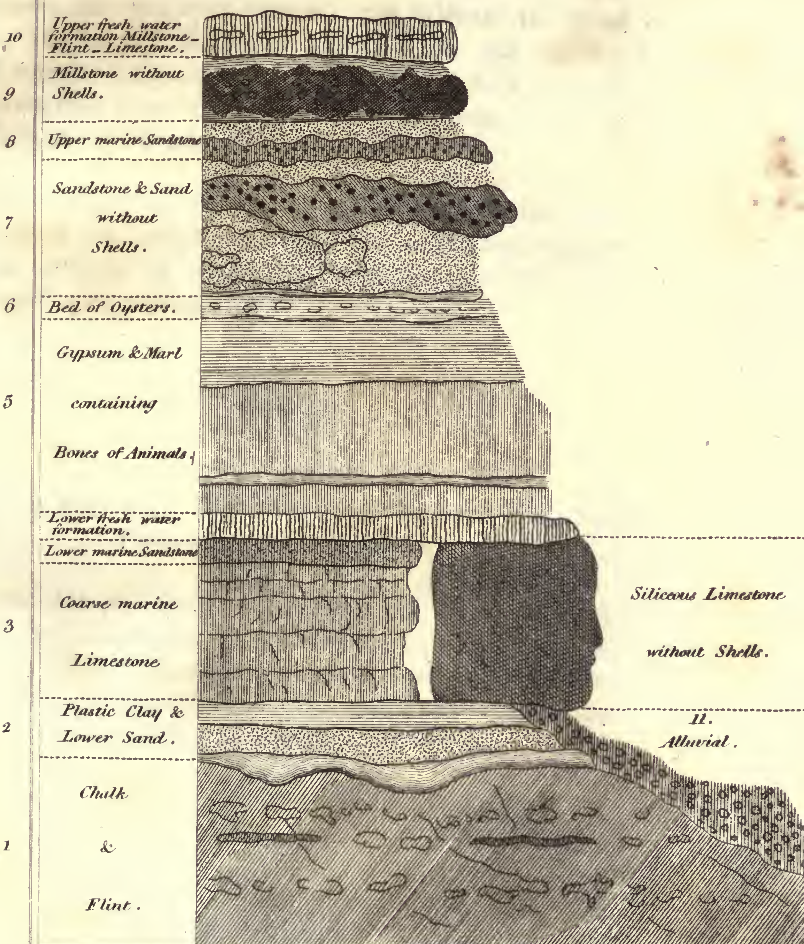
A. Anderson Sc.

PLATE III.

SKELETON OF THE MEGATHERIUM—Dug out of Alluvial Strata near Buenos Ayres.

PLATE IV.

PLAN
Shewing the relative position of the
MINERAL FORMATIONS
around
PARIS.



A. Anderson Sc

New-York, Publish'd by Kirk & Mercein, 1818.

will be noticed in the sequel, that the summit of Michillimakinac contains the shells of bivalve molluscas, and consequently must have been covered with water. The supposed dam confining the water in former ages, reached from the extremity of the Cumberland mountain to the Missouri hills. And by the flood which effected its demolition, the vast tract behind it was drained, the lakes Erie, Huron and Michigan were formed, and the dry land appeared around; while the ruins of sand and soil were carried down the valley of the Mississippi, and deposited on the alluvial bottom there.

These imperfect traces may serve to give some conception of the former geography of North America, and of the changes by which that configuration has been changed to its present state.

A List of some of the Organic Remains deposited by the Salt Water before it was drained off.

A middle-sized oyster, entire, from the neighbourhood of Sackett's Harbour. The shells are in their proper situation, cohering in such a manner as to exhibit a perfectly natural appearance. The specimen brought by David B. Ogden, Esq. is in high preservation.

From the county of Ontario, a petrified oyster, six inches long, and four broad, was lately brought to me by Mr. Isaac Adriance. The valves of the shell are a little disclosed, and the space between them filled with a black fetid limestone. Near the opening where the

specimen was broke from the quarry, the stone exhibits a pecten and a terebratula, and an univalve shell resembling a turbo.

The fountain of sulphuretted water at Clifton, about eleven miles northwest of Geneva, in the county of Ontario, rises from a rocky stratum filled with organic remains. These are mostly madrepores of singular and fantastic forms, differing from any at present found fresh and growing in the ocean. The limestone is of the fetid kind (lapis suillus), and abounds with sulphur and hydrogen. These sometimes escape together, and are sometimes extricated in their separate states. When they accompany each other, they make sulphuretted hydrogenous gas. When there is no brimstone, the inflammable air rises without it, producing burning springs; and when there is no hydrogen, the sulphur often oozes out and trickles down without it. Both are probably derived from the abundant animal matter with which the rock abounds.

Shells and impressions of scallops in the calcarious rocks around Sacket's Harbour and in the country adjacent to the Black river. The slab of marble brought by Major-General Brown, is one of the first-rate specimens of pectinite, wherein both the shells and the impressions are distinguished. The forms are plain and admirably traced. They differ from the species now found on our shores in a living condition, and, indeed, from every thing I have seen in the cabinets and the books. It is not improbable their race is extinct.

Orthocerites of large size, so as to be reckoned by some to be the back bones and ribs of sturgeons, are frequent in the calcarious rocks around Sackett's Harbour.

Those forwarded by Dr. Francis Le Baron, are bedded in fetid limestone of a very dark colour. The spaces whence the shell had disappeared are sometimes filled with white calcarious spar. The appearance of the petrifactions is thus very strikingly diversified. In other cases, the shell itself, though altered or petrified, remains.

Madrepores, of various magnitudes and kinds, occupy places in the strata of this calcarious carbonate. The central part of a very large one in my collection, exhibits a kind of radiations intersected by concentric circles. Some of the spaces or cells between them are yet empty, and others filled with a more newly formed calcarious substance. This probably belonged to a species now extinct.

A neat topographical description of this region was written in 1809, by Dr. Hugh Henderson. After having been read before the Central Medical Society at Albany, it was printed in the Medical Repository at New-York, (vol. xiv. p. 21—27.) He states expressly, " that there are such distinct traces of marine shells in all the stones he had yet seen, that he cannot resist the belief that either at the flood or some period since, this country has been inundated by the waters of the lake." This intelligent writer states in his memoir, the conjecture, that at the Thousand Islands, the attrition of the water had worn down the primitive rocks of granite, and reduced the stream to its present dimensions.

My own observation has assured me that to the westward of the Little Falls on the Mohawk, remains of oceanic animals are found, sometimes in limestone, sometimes in argillaceous shist, sometimes in very white sand-

stone, through the whole distance to Upper Canada: Near Utica, encrinites and hippurites, as well as pectinites, are found in the shistic strata; as are other regular though fantastic forms of bodies evidently organic. The white sandstone of Cayuga contains bivalve shells, which I take to be a species of fluted cardium or cockle. The rest of these petrifactions consist chiefly of marine shells and madrepores preserved in fetid limestone. The shells are mostly of the bivalve order, consisting of scallops, clams and cockles, with a few oysters, all consolidated into rock. The madrepores are various, some representing the forms, as the people say, of buffaloes' horns; others of honey-combs and hornets' nests; and others again of riddles and sieves; and other odd comparisons, as of cow dung, &c. all petrified.

These are so frequent and so numerous, that through the whole of this extensive region the rocks are studded with them.

Near Oxford, in Chenango county, New-York, the mould of a very large and singular terebrum or screw shell was formed in a quarry of red sandstone, and forwarded to me by the Hon. Uri Tracy.

Among the organic substances, those found near Wilkesbarre, in Pennsylvania, are not the least curious. In that vicinity there is an extensive formation of shining coal, of the kind that is somewhat difficult to burn, and which emits but a small flame. The strata that cover this coal are a sort of argillaceous slate, that contains numerous and plain impressions of ferns and other capillary plants, and of the bark of palm trees. I am indebted to Mr. John Bradbury for the specimens which are impressed with these remarkable characters.

In relation to lake Ontario, the following statement concerning the appearances on its southern side were made by Dr. Clinton, in his address to the Historical Society:

"From near the Genesee river to Lewiston, on the Niagara river, there is a remarkable ridge, or elevation of land, running almost the whole distance, which is seventy-eight miles, and in a direction from east to west. Its general altitude above the neighbouring land is thirty feet, and its width varies considerably; in some places it is not more than forty yards. Its elevation above the level of lake Ontario is, perhaps, one hundred and sixty feet, to which it descends by a gradual slope, and its distance from that water is between six and ten miles. There is every reason to believe that this remarkable ridge was the ancient boundary of this great lake. The gravel with which it is covered was deposited there by the waters, and the stones everywhere indicate by their shape the abrasion and agitation produced by that element. All along the borders of the western rivers and lakes there are small mounds, and heaps of gravel, of a conical form, erected by the fish for the protection of their spawn: these fish banks are found at the foot of the ridge, on the side towards the lake; on the opposite side none have been discovered. All rivers and streams which enter the lake from the south have their mouths affected with sand in a peculiar way, from the prevalence and power of the northwesterly winds. The points of the creeks which pass through the ridge correspond exactly in appearance with the entrance of the streams into the lake. These facts evince, beyond a doubt, that lake Ontario has receded from this elevated ground; and the cause of this retreat must be ascribed to its having enlarged its former outlet, or to its imprisoned waters

(aided, probably, by an earthquake) forcing a passage down the present bed of the St. Lawrence."

That enterprising officer, Major Long, of the corps of engineers, forwarded to me a box of minerals and fossils from the Illinois river and its vicinity, and from the region adjacent to the junction of the Missouri and Mississippi. Organic remains of bivalve molluscas, and of some other beings, probably animal, to me unknown, are contained in the flinty masses along the Illinois its whole course, from Chicago, near lake Michigan, to the Mississippi; and shells and madrepores abound in the limestone around St. Louis, and down the Mississippi to St. Genevieve and beyond.

In the geological chapter of the *Picture of Cincinnati by Daniel Drake, M. D.* (p. 64—67), the strata through the extensive region of which that district is a part, are represented as a secondary form—"a vast precipitate from a lake or sea of salt-water." It is a limestone of two kinds, one ancient and the other modern. The latter, of a grayish-blue colour, surrounding Cincinnati, contains, according to this respectable writer, vestiges of the following species:

Anomia terebratula.
——— placenta.
Belemnites.
Ammonites.
Entrochites, in flint.
Corallines, in flint and limestone.
Madrepores, } always siliceous.
Tubipores, }

With many other kinds, which Dr. Drake supposes a skilful naturalist could ascertain.

Changes wrought within these Limits subsequent to the bursting of the Barrier, and in consequence thereof.

After the subsidence and removal of the briny waters through so many passages, the streams fed by the rains and springs retiring to their channels, seem to have wrought other alterations, a few of which deserve to be mentioned. Travelling down the inclined plane from their several sources to the new level of the lakes, they have given a configuration of a more recent and modern date to the regions through which they pass.

Among these are—

The falls and rapids in the Black river.

The falls and rapids in the Onondago river, a few miles above Oswego.

The fall in Salmon river.

The rapids in the Seneca river, near the outlet of the Seneca lake and at Jack's rift below.

The cataract in the Genesee river.

The grand cataract in Niagara river, which, from its just celebrity and grandeur, merits a more particular description. There is reason to believe it deepened its channel through the rocks between Chippeway and Schlosser, and by that operation contributed further to lower the level of lakes Erie, Huron and Michigan.

The cataract has employed so many pens and pencils,

that I should not write any thing about it, did it not appear to me that the great chasm which the water has formed in the rocks at that place, discloses much of the mineralogy of the region, and assists in forming correct opinions concerning the geology of this section of the globe. The delineation by Mr. Weld is reputable to him; and his pages and illustrations instructive. The account by Mr. Volney is intelligent; and his plans perspicuous. The paintings and prints of Mr. Vanderlyn, are pieces which present to the eye, all that can be expected from landscape. The description of Mr. M'Kinnen, although it is almost as much a picture of his own emotions as of the scenes around him, is nevertheless ingenious and interesting.

On exploring the strata laid bare by the cataract, their argillaceous, calcarious and siliceous character immediately struck me. I was careful to bring away specimens of each; and these, at all times and distances, enable me to substantiate my own description of the grand falls.

The lowest of the strata as yet reached, is the rock called by geologists old red sandstone. It is composed of quartzy particles, with a cement of clay and iron. The latter being in the form of reddish brown oxyd, imparts its colour to the rock. Below the ridge which crosses the stream at Lewistown and Queenstown, the layers of this ancient sandstone make their appearance. It, in all probability, underlays the slate, limestone, and soil, to a great extent.

The next layers of earthy matter at the falls are composed of slate, or shistus. This is very friable, and cracked into numberless pieces. It has so little cohesion that the fragments can be easily picked out by the fingers.

It is constantly dropping off or wearing away. Its fallen portions constitute a part of the loose gravel through which the traveller labours, beneath. This substance yields to mechanical and chemical agency more readily than the harder strata which it supports. It therefore undergoes excavation, while the superior and firmer strata of limestone project and overhang, until they break off by their own weight. Owing to this abrasion or decay of the brittle shistus, the calcarious rocks above, jut far beyond their present base, and threaten him who takes shelter below them. Masses of various sizes, from small stones to rocks of many tons weight, have fallen from the summit thus undermined, and now occupy the space at its foot. As the excavating or undermining process goes on, other pieces will be detached, and the chasm be proportionally enlarged. This foundation of slate is of vast extent in these parts of North America. Shistus emerges from the strata of granite on the banks of the Hudson, at Newburgh and Fishkill, and underlays the limestone to the northward of both; as well as the sandstone of the Catskill mountains. Travelling north, it shows itself again at the water-falls in the neighbourhood of Albany, and at the village of Waterford. The same kind of argillaceous slate prevails beyond Stillwater to the falls of Fort Edward, and supports the limestone over which the Hudson at Glen's falls is precipitated. Turning westward, the shistus, over which the Mohawk river falls at the Cohoez, is covered with granitical stones and rocks from Schenectady to Palatine; and at the latter place, by a limestone that is replete with petrifactions. At the little falls where the lock-navigation has been opened, huge strata of a compact, striated, dusky and ferruginous quartz conceal it. At Utica a coarse, granulated, siliceous sandstone overspreads it. But at Oriscany the slate again makes its appearance, and continues until the

limestone incrusts it, west of the Oneida reservation, in the town of Sullivan. And it probably extends under the calcarious strata quite to Niagara river, and an unknown distance into Canada. At the former place, the impetuous action of the water has exposed its deep stratification. Shistic rock abounds in the region between the Hudson and the Mohawk; for at Ballstown, some of the branches of the Kayaderossras have washed the strata bare. And the banks of the St. Lawrence from Quebec to Kingston on Lake Ontario, demonstrate the prevalence of the slate as the extensive substratum in all that tract of country.

The rocks which press the layers of friable shistus at Niagara, are limestone. They are disposed horizontally, and are of the flat or tabular form. Their strength and compactness enables them to overhang the banks, after their foundation of brittle slate has been removed. One of the most prominent and durable of these strata is the *table-rock*. This is much frequented as a favourable spot for observing the magnificent scenery from above. While it lasts, it is worthy of being resorted to, for the advantages of the prospect it affords. And it may be regretted, that it will be spoiled whenever the slate beneath shall be so far worn away as to render the incumbent strata of calcarious matter incapable of supporting their own weight. The projecting portions will break off, and descend by their gravity to the subjacent mass of ruins. The fear of danger to a spectator standing upon such a ponderous shelf, and surveying his situation when above, is not surpassed by the solemn apprehension he experiences from its imminent and awful aspect when below.

In these calcarious strata, the carbonate of lime predominates. This, however, is not a mere mixture of

fixed air with an earthy calx. The rock on being rubbed or broken, emits a fetid or sulphureous odour; evincing that it is a swine-stone or *lapis suillus*. This disagreeable smell attends the limestone in this and the adjacent regions. I possess pieces of it charged with martial pyrites. And the sulphur, clay and iron of this association, are intimately blended with the calcarious carbonate. The existence of pyritical limestone explains how, by the decomposition of the pyrites, sulphuric acid is produced, and gypsum formed.

The calcarious nature of the upper rocks is evinced by the fact, that in the neighbourhood of the great cataract as well as at the whirlpool five miles down the river, and at Queenstown, two miles further, the inhabitants burn them into lime for economical purposes. But the material is not always indeterminate or shapeless. It assumes beautiful crystalline forms. Rhomboidal and cubical crystals are formed on its surface, and in its cavities. The former are of a milkwhite colour, with oblique angles. The latter are less frequent, generally found in the same clusters with the others, of an almost rectangular figure, and of a semi-transparent complexion. Other crystals shoot along the vacuities of the limestone; some of an imperfect hexangular shape, and others in clumps of acute six-sided crystals, both having a resemblance to the dog's-tooth-spar. All these are probably modifications of the calcarious carbonate, by admixtures of magnesia, iron, silex, and perhaps some other ingredients.

The layers of limestone are interspersed with small masses or lumps of gypsum. This is generally of a snowy whiteness, and indeterminate figure. But it is sometimes finely semi-pellucid and lamellar. It is mis-

taken by the people for the petrified froth of the river. It seems to be formed in consequence of a decomposition of the pyrites imbedded in some parts of the rock. The sulphuric acid to which this process gives rise, expels the carbonic acid, and unites with the limestone by virtue of a more powerful attraction. Thus the common limestone is converted into plaster of paris; or in chemical language, the carbonate of lime is changed into a sulphate. The two compounds very commonly exist together, the limestone and gypsum cohering and making parts of one mineral mass. In some rills where the brimstone appears not to have been combined with oxygen, it oozes out with the water, and discolours the rocks. Thus native sulphur and calcarious sulphurets, may be enumerated among the natural products of Niagara.

The siliceous ingredients in the rocks hereabout consist mostly of quartz and flint. The quartz is sometimes mingled with the calcarious carbonate in such quantity as to give sparks with steel; forming a sort of siliceous limestone. In other cases it exists in veins or streaks almost unmixed. And lastly it bespangles the surface with elegant crystals, hard enough to scratch glass. The flint at the falls is whitish; but near the outlet of lake Erie it is blackish. In both places it is distinctly bedded in the limestone; and their quantity is relatively small, particularly at the former place. At the latter, the colour of the flint has concurred with that of the calcarious strata in which it is immerged, to obtain for the spot the name of *Black rock*. This stone breaks with the concavo-convex fracture; and answers very well to furnish fire-stones for muskets. It does not seem to be chemically incorporated with the limestone; but to be laid in it as pebbles are scattered through breccias. It puts me

in mind of the nodules of flint, contained in the chalk-pits of Kent and Surry, near London. The flint and limestone at Erie lie contiguous without mixture; and may be broken out in their respective forms quite distinct. And this connexion of them continues eastwardly, far into the Seneca-prairies, or Buffalo Plains.

Such is the constitution of the solid strata at Niagara, and in its vicinity. The uppermost are horizontal and tabular. When a stratum is discontinued, its termination is abrupt, forming a sudden descent. This descent, at any one place, is proportional to the thickness of the stratum. Several of these strata break off in this manner, about half way between Chippeway and the grand cataract. And they continue their interruptions to the evenness of the channel, the whole distance beyond. At each termination the river treads lower, and skips and dances along to the next. It marches down this, and proceeds to the succeeding one. Then it runs from stage to stage, until, after a gradual and majestic progress of a mile, gathering force and velocity at every step, it leaps from the high and final precipice.

The mighty and immeasurable torrent dashes upon a ledge of detached and enormous rocks, the fragments of the superior strata that have been broken off, and precipitated in the course of ages. All the pieces which the vehement and unceasing current can stir, are washed away. None remain but those that are too heavy for removal. These form a rough and broken bottom for the floods to rush upon. Their solidity and size check the impetuosity of the headlong river. Their crags convert a part of it into mist, which rises like an exhalation to an altitude sufficient to be seen for many miles, and which bedews the adjacent district with a moisture resembling

rain. On the Canada side, they are in a great degree concealed from sight by the foaming water, and the rising spray that invest them. But on the New-York side, where the height of the fall is greater and the quantity of water smaller, owing to a dip to the west or rather northwest, the inferior ledge of rocks can be better discerned as they lie piled upon each other in all the rudeness of accidental disposition; these form a barrier to protect the basis of slate and sandstone from the assault of the water. By the intervention of these impassive heaps, the shistus, notwithstanding its shattered constitution, maintains its ground remarkably, and yields but slowly. Yet, under the operation of such powerful causes, it gives way at last, though only inch by inch. In consequence of this moderate, but certain removal of the shistic foundation, the calcarious strata are at length deprived of their support, and yards and perches, as is believed, of their extremities have disappeared within the recollection of persons now alive.

By this means the cataract seems to have moved its place, and not to have been stationary at any one point. Beyond a doubt, it is proceeding up the stream, and drawing nearer to Chippeway and Erie. And if in its early existence, it thundered where Queenstown now is, it must have worn its way about seven miles in the lapse of centuries, to its present seat. Strange as this conjecture may appear, to many it really violates no probability. On the other hand, it is countenanced by several important considerations. A little above that village, the plain which reaches northwardly from the shores of Lake Erie, ceases. There is a rapid declivity to another plain which extends to Ontario. The difference of these levels is rather more than the height of the falls. The beholder is impressed with the belief that the river once

ran to this natural limit, and there descended to its lower bed. If this really was the fact, it could not have continued to flow for ever there. The deep foundation is the same species of sandstone and shattered slate which sustains the strata where the falls now are. The incumbent beds of rock are but continuations of those very calcarious layers; with the addition of some siliceous sandstone between the top and bottom, along the declivity of Queenstown. What marvel then that the river should have opened for itself its present profound channel through rocks of such a stratification and so constituted? There cannot be a moment's hesitation in the mind of every examiner to admit the readiness with which the slaty strata, cracked through with innumerable flaws, would be dislodged by the force of such an agent. Their minute fragments of loosely cohering particles, would immediately be carried along by the tide. By attrition they would be worn away, and lay aside their shistic form on returning to argillaceous powder. Thus the strata of slate would naturally disappear and leave a passage for the waters. In the meanwhile the limestone, deprived of its support beneath, would separate piecemeal and tumble into the abyss. Every person of science knows that calcarious earth is soluble in water, and that it is liable also to alteration through the chemical and mechanical agencies to which it is subjected. The firmest limestone will, after sufficient agitation and exposure, lose its coherence and be transformed to sand, or vanish in solution. In either case, whether the rocks are pulverized or dissolved, the greater impediments are removed and an opening made for the river. And really when it is considered what vast power water possesses as a menstruum, and how irresistibly it acts by impulse, there will be reason enough to conclude that the channel from Queenstown to Chippeway may have been worn between

its rugged banks by that agent. It will be equally evident that the work is by no means suspended; but that the wear and tear is incessantly going on.

B. F. Stickney, Esq. has written some valuable geological observations on the middle lakes or seas of North America. He states that the elevation of the land between Michigan and the Mississippi levels does not exceed eighteen feet; and that boats pass, three or four months of the year, without difficulty. This ingenious inquirer asks, whether a dam, twenty or more feet high, across the strait of Niagara, would not raise the middle lakes high enough to discharge by the southwest toward the gulf of Mexico? It violates no probability to suppose it formerly was so.

The falls of the Ohio near Louisville and the Rapids, and its numerous and tributary rivers and streams from Pennsylvania, Virginia, Ohio State, Kentucky, Illinois and Indiana, all hurrying down their slopes with increased velocity and force, and producing constant changes by their alterations, torrents, and floods.

And lastly, I enumerate in this place the falls of St. Anthony in the Mississippi, as situated within the limits circumscribed by the great dam or barrier already traced.

Besides these traits of our country's character, by the evacuation of the great inland sea, by the formation of alluvions at the several openings and places of rupture, by the production of rivers within the region anciently occupied by that sea, and by the appearance in the uncovered rocks of marine productions in almost every part of the tract; there is another class of phenomena,

relating to the organic remains of a later date. These embrace the remains of land animals, found in a fossil state, not imbedded in the rocks, but simply buried in the loose soil.

Kentucky has been distinguished almost ever since its discovery by white men, for the extraordinary number and size of the bones found at different depths, from one foot to twenty feet, in the neighbourhood of the Licks, or places resorted to by wild animals to regale themselves with the briny water that oozes out at those spots. The place most celebrated for these animal remains, and particularly for those of the Great Mastodon, or American Mammoth, is generally distinguished by geographers as the Big-Bone-Lick.

This spot was profoundly explored by Governor Clarke, in 1807, at the request of Mr. Jefferson, then president of the United States; a citizen who has already received the applause of the learned and the wise, by the exertions which he made, himself, to promote natural and physical inquiries, and by the employment of competent persons in various instances to explore the unknown regions of North America. After the return of the former gentleman from the expedition to the Pacific Ocean in 1806, he caused the soil of the Big-Bone-Licks to be dug up. Bones were found in great number and variety. They were carefully enclosed in boxes, and forwarded to Washington City, in the district of Columbia, by the way of New-Orleans. They arrived in safety about March, 1808. Being then a senator in congress, I had repeated opportunities of seeing the whole collection displayed in the president's house, and of hearing Mr. Jefferson discourse upon them. I understood that he made a triple division of them, sending one-third to

the American Philosophical Society, at Philadelphia, of which he was then the presiding officer; forwarding one-third to the National Institute of France, of which he was one of the foreign associates; and reserving the remainder for his own museum.

This extraordinary assemblage of fossil bones, I arrange under the following heads: 1. Many dozens of the smaller bones, apparently of the mastodon, which seemed to have belonged to the feet. 2. Bones of the legs, discovered partly in connexion with the former, and partly scattered as they were, through the soil. 3. Bones of the head and upper-jaw, which afforded expectation that more would have been learned from them than was before known, of the structure of these perishable parts. 4. Two kinds of teeth, of very large size, and detached from the jaws; some of these teeth evidently belonged to the mastodon, being distinguished by their elevated processes; while others more nearly resembled the elephant's grinders. 5. Fragments of lower maxillary bones, containing the grinders fixed in their sockets. These jaws were mostly broken through the symphysis of the chin, and none of them were entire. 6. An enormous outer tooth or tusk, resembling that of the elephant. It consisted of ivory; but had laid so long in the ground, that it was decayed at both extremities. The curve was a singular sort of spire. The ivory, on account of the decay it had undergone, flaked off, like layers of rotten wood. 7. Several small tusks, the smallest of which was about three feet long. They are of remarkable specific gravity, decayed and broken at the ends, and disposed to split and crumble to pieces by the exposure to the air. 8. Ribs, of the shape common to the skeletons of mastodons. 9. Very large vertebræ. 10. The skulls of buffaloes or bisons, with the

bony cores of their horns. The horns were missing, but the bony enclosure very entire.

Kentucky abounds with marine relicks. In my possession is an echinus of the family galerite. It was found fossil, and so charged with siliceous particles, as to be insoluble in acids. I received several of them from Dr. Samuel Brown, and Professor Woodhouse. They are detached, and about the size of a middling acorn.

In Indiana, bones of the like huge creature were found July, 1817, in the east branch of the White river, a stream emptying into the Wabash, at a point distant forty-four miles in a right line from the mouth of the Wabash. This east branch unites with the west branch, at a point twenty-nine miles in a direct line from the mouth of the White river. The intelligence was communicated to me by Josiah Meigs, Esq. commissioner of the general land office, in the treasury department of the United States, who received it from Mr. Spotts, living near the falls of East Branch. These consisted, it is stated, among others, of the upper jaw, whose width from outside to outside, was 20 $\frac{1}{2}$ inches; length 25 inches; length of the posterior grinder, (composed of 5 divisions in 3 rows) 7 $\frac{3}{4}$ inches; breadth of the same across, 5 $\frac{1}{2}$.

The accounts published of similar remains of mammoths, found near Bedford, in Pennsylvania, belong to this place; because they show that these animals inhabited the land after the sea had retired, and it had become a fit abode for terrestrial quadrupeds.

The celebrated tusk found at Chenango, in New-York, near the point where the Susquehannah passes into Pennsylvania, evidently belonged to an animal of the same

species; a quadruped of the elephantine family, now probably extinct.

Of this species appears to be the animal, whose remains were brought by Major Craig from the banks of the Ohio, in 1786. They consisted of a thigh-bone, part of a tusk, and a portion of the jaw with the grinders. They were figured by Colonel De Brahm, and published in the Columbian Magazine, at Philadelphia, vol. I. p. 103—107.

Lakes and Dams, which formerly existed on the outside of the cordon or barrier already described.

Though these supposed collections of water were situated on the outside of the dam herein-before traced, as reaching from the Thousand Isles, in Canada, round to Cape Girardeau, in Missouri, yet they appear to have given to the country a character and configuration too important to be omitted in this memoir.

1. The lakes, breaches and alluvions of Connecticut river.

Some persons suppose that a dam existed in former days at Bellas' falls. If so, there must have been a lake above them. When that lake was exhausted or run out, dry land was brought to view, and a wash of moveable matters carried to the region below.

If we can suppose that there was once, at one or more places in Massachusetts and Connecticut, higher up than Hartford, dams and lakes, then it will be evident that the breaking or disrupture of such dams would inundate the lower country, and cover it with a

mixture of alluvial matter mingled with detached masses of primitive rocks.

It is agreed by all our geologists, that the region situated on both sides of Connecticut river, and extending from the northern line of Massachusetts to Long-Island Sound, is secondary or alluvial. They may inquire further whether there is any connexion between such ancient bursting of dams, and the deposition of earthy and rocky materials in the spaces below them. Should the secondary formation thereabout be not referable to this cause, there will be no difficulty in ascribing to it, a part of the alluvial character of the tract.

Here I may mention the impressions or forms of fossil fish, found in the town of Glastonbury. They are contained in a black bituminous shist interspersed with fine particles of mica. Though in the specimens I possess, the tail, scales, and fins, are perfectly distinguishable, the specimens are too much broken to enable me to decide upon the genus and species. My exertions to procure an entire ichthyolite from that place have not as yet been successful.

2. The falls, breaches, and derelictions of the Hudson.

About fifty miles north of Albany, near Kingsbury, is a very picturesque and magnificent scene. The whole waters of the Hudson fall down a considerable steep. The country from about two or three miles above the falls, called Glens' falls, to some distance below them, abounds with calcarious rocks, and with a sort of black trap. They are at that place the upper strata, and rest upon the shistus or slate, which forms here, as at other parts of New-York state, the solid mass of earthy mate-

rials below. A thick and massy bed of this rock crosses the river a little above the place where it descends. The rock there divides itself into so many distinct masses, that when the water is low or scanty, it runs through four different chasms between the walls. When the river is swelled with rains, all these fissures and interposing mounds are covered up, and the distinction of current is in some measure lost for about half the distance of their irregular descent. The streams then assume a new modification, and arrive at the bottom by three principal channels. The rocks which directs the courses of the waters, and separate their currents, are almost as horizontal as if they had been laid by a level. In several places they are very abrupt, and terminate with the perpendicularity of a wall. Between them are the profound openings through which the torrents force their way.

These strata abound in shells and madrepores. In the lowest they are least conspicuous. In the middle layers they are plainer; and most distinguishable above. The collection of fossil specimens made by Mr. Milbert and Trecot, now in my possession, afford beautiful illustrations of this distribution of organic relicks through the rocks.

Other features of this region are equally remarkable. The surrounding scenery is a medley of detached granite and gneiss, with sand, and other loose alluvial materials. These evidently were washed down from Hadley, when the enclosed waters removed their barrier, and bore every thing before them to this lower country.

At Fort Edward Falls, the bed of the Hudson is slate. This shistic bottom is visible all the distance, wherever

the sand and gravel have been washed off, to Troy, and the great falls of the Mohawk. The fine scenery along the Hudson at Glen's and Hadley's falls, has been so elegantly sketched by Mr. Milbert, that his paintings give interest to geology. The descent of the river toward tide-water at Troy, is interrupted by several smaller falls and rapids running over layers of slaty rock. This continues until the Mohawk joins it from the west. Their united current passes along without any memorable impediment until it arrives at the Highlands, a range of mountains crossing it a little to the southward of Newburgh and Fishkill. They are composed chiefly of granite and gneiss, abounding in loose nodules and solid veins of magnetical iron ore. The width of the chain may be rated at about sixteen miles. The height of the most elevated peaks have been ascertained barometrically by Captain Alden Patridge, of the corps of artillerists and engineers. According to his observations, Butter-Hill, on the west side of the river, is 1529 feet above tide-water, and the new Beacon 1565 feet.

This thick and solid barrier seems in ancient days to have impeded the course of the water, and to have raised a lake high enough to cover all the country to Quaker-Hill and the Taconick mountains on the east, and to the Shawangunk and the Catskill mountains on the west. This lake may be calculated to have extended to the Little Falls of the Mohawk, and to Hadley Falls on the Hudson. Geometrical surveys, and geological facts, countenance the belief, that a lake covered the whole space between the mountains on the east side of lake George and the Green Mountains in Vermont, and made a continued body of water to lake Champlain, as far above Montreal, as the foot of the ancient barrier already described as having existed anciently at the Thousand

Islands. The information given me by Colonel Garin, a skilful engineer, employed by the canal commissioners, in 1816, to explore the region between the Hudson and the lake Champlain, warrants this conclusion. Indeed, such an overflow of the country is the unavoidable consequence, that an obstruction of the water by the Highland mountains in New-York would produce.

Upon this supposition, what mound or dam would circumscribe the lake or sea, on the northwest, north, northeast and east?

If our physical geographers are correct in their delineations, a barrier to the waters can easily be found. Such as, for example, the ridge that bounds the Seigneuries, and their augmentations of land N. W. of the river St. Lawrence, and separates them from the waste or ungranted territory of the British crown, all the distance from the Grand, or Ottowa river, in Upper Canada, to the sources of the rivers Jacques Cartier, and Charles, not very far from Quebec in the lower province. And such is the height of ground, elevated though broken, which extends through the rough country, beyond the river Chandiere, from the river St. Lawrence, to the mountains of Maine and New-Hampshire.

Some opinion may be formed of this disruption by the considerations of that sensible traveller, Joseph Sansom, Esq. describing the Plain of Abraham, near Quebec. He observes thus: turning round when you arrive at the summit, and looking down the river, between the two steeples of the Catholic and Protestant Cathedrals, you have what I thought the most interesting view of Quebec, because it embraces in the same *coup-d'œil*, the principal objects in the vicinity. Overlooking the basin

which is six miles wide, you behold the Island of Orleans, stretched out before you, till it terminates in undistinguishing haze, whilst on the left you have the north coast, rising gradually into distant mountains, from which the river Montmorency, precipitating itself into the St. Lawrence, is all but seen, through a grove of firs, and the view terminates abruptly in the perpendicular promontory of Cape Tourment, which is two thousand feet high, and therefore may be distinctly seen at the distance of thirty miles. On the right you have the rocks of Point Levi, and behold the shipping in the harbour, at an immense depth below. Imagine the effect of this whole fairy scene, connected as it is by the broad surfaces of the river, which is seen again upon the edge of the horizon, winding round the stupendous bluff abovementioned, in its course toward the sea."

This connexion being established, there is no difficulty in continuing it to the Green Mountains of Vermont, and their continuation through Massachusetts and New-York to the Highlands already mentioned, as passing the Hudson to the southward of Fishkill and Newburgh.

On the west side of the Hudson, this barrier, called by the various names of the Highlands, the Fishkill, Skunemunk, and Haverstraw mountains, becomes the Suckasunny and Musconetcunk mountains, in New-Jersey. It passes the Delaware to the southward of the places where the Lehigh and the Musconetcunk rivers fall into the Delaware. It then continues its course southwestwardly, crossing the Schuylkill below Reading, the Susquehannah south of the Swetara, the Potomac above the Great Falls, and so on further than I have been able to trace it; being however associated with the Short Hills

in Virginia, and ultimately with the south mountain on the Atlantic side of the Shenandoah.

Thus the second, or outer barrier, embraced a large extent of country, reaching from Canada to Virginia.

The Breaches made about fifty miles north of New-York City.

A geologist finds traces of three openings for the imprisoned waters; one through the eastern barrier, and discharging near the boundary of New-York and Connecticut, into Long-Island sound; another through the valley called the Clove, where the Ramapaugh river now runs; and the third through the Highlands, where the Hudson to this day glides along. Through these several passages, the country from the Highlands to Glens' Falls and the Little Falls of the Mohawk, in length, and from the Shawangunk mountains to the Taconick, in breadth, may be supposed to have been drained.

Let the explorer of the scene behold the fossil and organic remains which have thus been laid open to inspection.

At Palatine, near the place where the Canajoharie Creek joins the Mohawk, the limestone rocks abound with sea-shells, chiefly, if not altogether, of pectens, anomias, and other bivalve species.

Here I mention the fossils of Cherry Valley, situated between lake Otsego and Canajoharie, south of the Mohawk. Cadwallader D. Colden, Esquire, represents, on the authority of Mr. Morse, that petrifactions are very frequent. They consist of " marine shells, horns of

land animals (probably ammonites or spirulas), and plants; all in the same place. They are found on the deepest valleys and the highest hills. The valleys mostly bedded with limestone; and in the midst of large masses of this, the petrifactions are found. As you ascend to a certain height, the hills on each side of the valley, the limestone disappears, and the soil is totally different. Confused masses of the slate kind are found, some lying horizontal, others projecting from the ground at an angle of about forty-five degrees. In the midst of these masses of slate-rocks are found the same petrifactions."

The whole ridge called the Helleberg, about twelve miles west of Albany city, is a sort of argillaceous limestone, made up as it were of pectens, terebratulas, spirulas, and oceanic relicks. It was here that the very large and highly remarkable spirula was discovered, which Simeon De Witt has circumstantially described. His narrative, with a figure, may be seen in the Medical Repository, vol. 10, p. 350.

Within the limits of Coeyman's patent, about twenty miles south of Albany, there is a great body of Lumachella marble, disposed in regular strata. Attempts have been made to work it; but the quantity of siliceous matter with which it abounds, renders it hard and difficult to polish. Its constitution is very curious. The slabs I received from Roger Strong, Esq. and which are now in the mineralogical cabinet of the New-York Institution, contain a variety of animal remains, and all of them oceanic. Among these are—

Belemnites.
Anomias.
Encrinites.

Terebratulas.
Pectinites.
Ostreas.
Cardiums.
An Echinus, with its radiated prickles, or something resembling it.

Near the village of Claverack, is a large mass of calcarious rock, resembling a hill at a distance. It abounds with shells and their impressions. The foundation of the old court-house at Claverack, was built of the stone abounding in these petrifactions. The relicks here are mostly bivalve, being terebratulas, pectens, and some singular other forms.

To Peter Wynkoop, Esq. I am indebted for the black marble, quarried from the strata westward of Kingston, and replete with marine shells.

In Greene county, one hundred miles from the Atlantic coast, organic remains are found. Those brought by Mr. Frederic W. Porter, from the farm of Stephen Platt, Esq. at the village of Freehold, fifteen miles west from Hudson river, are the shells (not merely impressions) of pectens, terebratulas, and cardiums, bedded in a heavy and compact sort of siliceous clay, charged with brown oxyd of iron.

The like are found imprinted in clay-grit, or a sort of silico-argillaceous lumps, scattered over the farms for several miles north and south of Poughkeepsie; in many instances, the shells are wasted away, and the cavities they occupied, remain, together with their sizes and shapes.

The whole region watered by the Wallkill is scattered

over with organic remains; they overspread the fields; they appear in the stone fences; they show themselves in the walls of houses. From Warwick to Paltz and Esopus, oceanic relicks imbedded in stones, are constantly before the traveller's eyes. They are mostly loose, and mingled with the other nodules with which the country abounds; at least I do not recollect to have observed any stratified rocks thereabout, that contained them. Among them are many pectinites and terebratulas, with sometimes an oyster. But peculiar madrepores, corallines, and fulciments of polypes are of frequent occurrence. If I am not greatly mistaken, a young lady, Miss Anicartha Miller, brought me a stone at New Hurley, which contained a maritime plant, of the family of valva, or fucus, not petrified, but in its proper form. I am in possession of the real scale of a sturgeon, broke out of a stone at Shawangunk, and brought to me by Dr. P. S. Townsend.

The fossils of the Wallkill region, like those from Freehold and Poughkeepsie, are contained in a kind of wacke or killas, in which a mixture of fine clay and silex, is hardened by an impregnation of a brown or yellowish ochre of iron. I did not observe any of this class of relicks, lying unconnected, or in their naked state in the soil.

But there is another sort of testaceous productions, which deserve notice here. These are the shells and relicks of fresh water molluscas. They have undoubtedly made their appearance since the salt water was drawn off, and they form an era in the geology of this region.

These creatures inhabit certain pools or ponds of water, in the depressions or excavations which are frequent

in the land's surface. Generally they are fed by springs, and there is an outlet for the superfluous water, after the cavity is filled up by boggy, or turfy matter, and the quagmire overgrown by shrubs, trees and smaller plants. The learned world is greatly indebted to Silvanus Miller, Esq. for an admirable topographical description of this district. The shells of these inhabitants of the fresh water had been collected as long ago as 1803, by Dr. Samuel Akerly, and placed with the other specimens which constitute the body of conchology completed by his industry. Great praise, notwithstanding, is due to Thomas Say, Esq. for the skill and science he has displayed in the classification of these and other molluscas of fresh water; outstripping all his cotemporaries, and clearing the path for his followers.

The shells found in the pools are small and delicate, and are of the following species:

1. A carinated planorbis.
2. A plain planorbis.
3. A lymniæa.
4. A spirorbis.
5. A tellina.

Their remains, after death, dissolve to marl, or a white calcarious carbonate like chalk, easily effervescing with vinegar, and exceedingly valuable as a manure. Until the fertilizing properties of gypsum were discovered, these marl-pits were mines of wealth to the proprietors.

But, as it has been believed by some naturalists, that those shells belonged to marine animals, I state it as a fact, that D'Jurco Knevels has seen all the species just

enumerated, alive, in the fresh water brooks near Fishkill.

The vegetables growing in these little swamps, by their abundance and decay, furnished a great quantity of residue, which on drying is found to be inflammable; being in reality a kind of peat. In some places this is twenty feet, or even more, in depth, making a miry bog, in which every heavy body, capable of breaking through the turfy covering of roots and plants, immediately goes to the bottom. In many of them, a person who ventures on, may shake and agitate the tough surface for several rods around.

The region watered by the Wallkill is peculiarly the land of the American mammoth. The history of their teeth, tusks and bones, as discovered from time to time by the citizens, has already been written by Silvanus Miller, Esq. and Dr. James G. Graham. Their respective essays are recorded in the 4th volume of the Medical Repository. Mr. Rembrant Peale has also published an interesting account of the expedition made by his venerable father, Charles Wilson Peale, Esq. to this district, to obtain the materials from which he has framed the skeleton which gives interest and grandeur to his rich museum in Philadelphia. To these several sources of information I refer; observing, at the same time, that in this tract of country there have probably been discovered more fragments of mammoth remains, than in any other district of equal extent on the face of the globe. I refer to the writings of the late Professor Benjamin Smith Barton, of the ex-President Thomas Jefferson, and of Governor Dewitt Clinton, as great authorities on this subject.

I visited the tract situated near the Wallkill in the spring of 1817; and it was my fortune to assist in the disinterment of a mammoth.

On the 27th of May, I was at the house of Anthony Davis, Esq. in the village of Chester, near Goshen in Orange county, N. Y. Silvanus Miller, Esq. Peter S. Townsend, M. D. and Dr. Miller Wharry, had accompanied me there. We were met by Peter Townsend, Esq. of Newburgh, Dr. T. Seely, and by Messrs. William and Isaac Townsend, of Chester. During the evening the conversation turned upon mammoth bones; and Mr. Yelverton, who came in, said he knew where some of them lay, at the bottom of a ditch on his brother's farm, in the neighbourhood, dug by himself, nine or ten years before. In the morning I encouraged him to conduct us to the spot, and in a few minutes after the arrival of our company on the ground, he discovered the bones with an exploring rod.

The water of this small meadow had been drawn off by ditching. The soil had settled down; the cedar trees had died; the surface had been stubbed and smoothed; and it had been converted into a neat field of meadow pasture. The grassy sward was underlaid by about six feet of black peat, or fine vegetable inflammable matter. The sward and turf were about four feet thick over the bones. Beneath them, and immediately around them, was a stratum of coarse vegetable stems and films resembling chopped straw, or rather drift-stuff of the sea; for it seemed to be mixed with broken films of conferva, like those of the Atlantic shore.

It must be remarked also, notwithstanding the occurrence of marl, in the holes or ponds, that the snails and other creatures from whose shells marl is formed, do not

inhabit all of them. There are many in which there are none. Where the marl exists, it forms the lowest stratum, or lines the bottom of the pond. The peat and bog lay above it.

Whether the elephantine quadrupeds of former times visited these miry places for the purpose of food or drink, or for any other cause, they seem very frequently to have died in them. When their bones sunk through the mud into the layer of marl, they were secured from putrifaction by its alkaline and antiseptic quality. But when the mammoth expired in a swamp where there was no marl, the bones passed more rapidly into decay. The mud and water conspired to disorganize and destroy them, from the time that they settled to the bottom.

Those found by Mr. Peale had been preserved in a marl bottom, and were in sound condition.

The skeleton disinterred in my presence lay in a peat-bog, without the presence of marl. The bones were consequently more disorganized and rotten. I mean by this that they were not entire and firm enough to be extracted whole, far less to be connected together after they were raised.

The bones found were parts of the feet, legs, shoulder-blade, back-bone, rump, lower-jaw, and the upper-jaw, teeth and tusks.

The teeth were in good preservation. More than half the lower-jaw was entire. The condyles and angle of the other half, crumbled to pieces by handling. Yet the portion containing the teeth was taken up nearly whole. The exterior side was afterwards removed by

art to show the insertion of the grinders. Their appearance is represented in plate III. fig. 3. A view of the rest of the lower jaw, with its teeth, is given in fig. 2.

It was found that the upper maxillary bone, with its teeth and tusks, were there in their natural connexion. The opportunity was very favourable for discovering their junction. The meadow had been freed from a great part of its water by ditching; and a drought of long continuance had contributed to lessen the fluid. Measures were adopted on the 29th to free the pit from all its mud and water, and to uncover these parts of the head in the most careful manner. For this purpose Dr. Townsend and Dr. Seely descended into the pit, and removed the soil with their own hands. They discovered that the palate bones and grinders were uppermost, as if the animal had died on his back. The former of these gentlemen made a faithful sketch of the appearances exactly as the bones lay. The figure and connexion of the several parts are delineated in plate II. fig. 2.

The tusks were of different sizes, lengths and curvatures; varying in all these respects like the unequal horns of some neat cattle. Their appearance, as they were supposed to look, when the creature was erect in a standing attitude, is represented in fig. 3. The right tusk was the shorter, and its length was seven feet. It was thicker and blunter, in consequence, probably, of having been more used; and such employment of it, may be considered as the cause of its greater curvature. The left tusk was nearly nine feet long, and of a more regular, taper, and pointed form.

Finding it impossible to elevate the parts, by reason of their decayed and crumbling condition, Dr. Townsend took great pains to remove the soil and examine every part of the upper-jaw and head. His delineations of the form and structure of these parts of the skeleton, as correctly as he could ascertain them, by laying them bare and exploring every part, are given in fig. 1 and fig. 2.

The flatness of the cranium, the connexion of the tusks with the head by exsertion, and not by gomphosis, and the insertion of the grinders in them at their origin, will not fail to attract the attention of zoologists.

My own situation on the bank, only a few feet from the uncovered relicks, enables me to state my opinion of the fidelity and correctness of the drawings my friend has made.

After having then taken a summary survey of the fossils brought within our reach by the subsidence of the lake north of the Highlands, in consequence of the breaches in the dam which confined the waters, it is proper to inquire what were the effects produced in the districts below, or between that barrier and the ocean.

From the facts which I collected and published in the American Mineralogical Journal, in 1811 and 1813, it appears, that the whole of Long-Island is underlaid at a depth, varying from thirty to fifty feet, from its present surface, with a stratum of marine sand and gravel. In many places the well-diggers have found fragments of clam-shells and oyster-shells. The periwinkle or murex has also been discovered in New-Utrecht at the depth of

sixty-seven feet. Within the same strata which contain the shells, are often found boughs and trunks of trees, bark and damaged wood. For a large and conclusive body of facts upon this subject, I refer to the valuable work just mentioned, p. 129—133, and 261—263.

In addition to that mass of evidence, I now mention two more occurrences during the year 1817.

My brother, Judge Singleton Mitchill, apprized me in a letter received from him a few days ago (October) that in digging a well in his neighbourhood, on Cow Neck, at North Hempstead, and not more than a mile and a half from the light-house at Sands's Point, shells of clams and oysters were discovered at the depth of forty-five feet. On the same occasion a piece of wood was dug out, penetrated through and through by the teredo or pipe-worm. The facts are well known to the workmen and neighbours; and have since been confirmed to me in conversation.

Our graduate, Dr. Dering, brought, a few weeks ago, to the Lyceum of Natural History the fragments of clam-shells (venus), found in digging a well in Shelter-Island, thirty-five feet below the surface. Shelter-Island is situated between Gardiner's bay and Southold bay, within the north prong of the fork of Long-Island on one side and the southern on the other. It is nearly a hundred miles east of New-York city.

Since this marine alluvion has been hove up, a memorable change appears to have been wrought upon the north side of Long-Island. Vast numbers of loose rocks have been superinduced. They all appear to have been

detached from solid strata, and to have been rolled and worn since. They consist mostly of granite and gneiss. There are some huge masses of actinolite or radiated asbestos, and many of ponderous black shoerl among them. Stones of many kinds, consisting of quartz, shist, ferruginous oxyd, breccias, and pebbles formed of the granite and gneiss, abound every where among the rocks.

These loose and rolled rocks are most abundant in the towns of North-Hempstead and Flushing, particularly the former. Their great weight and bulk must have required extraordinary power to detach them from their primitive beds, and to have placed them where they now lie. Along the shores and over the fields, stones have been found now and then, in which organic remains of shells could be distinguished.

There is a ridge of hills upon Long-Island, separating it into two sections, the north and the south side. They extend from New-Utretcht in the west, to the neighbourhood of Southold in the east. They are highest in North-Hempstead, and gradually slope away on both directions until they disappear in King's county, near the Narrows, and in Suffolk, as they approach River-Head.

Their greatest elevation at the Harbour Hill, as found by Capt. Partridge, accompanied by Mr. Haines, Mr. Griffith, Professor Ellicott, Judge Mitchill, and myself, in the summer of 1816, is three hundred and nineteen feet. My letter to Mr. Dallas, then Secretary of the Treasury of the United States, (of October 16, 1816) contains the particulars of that expedition and experiment.

The north side of the Long-Island ridge of hills is so different from the south side, that a traveller naturally

asks whence came the rounded rocks and stones which occupy the north side, while there is not a pebble as large as an egg, on the south? A geologist may probably answer the query, by deriving them from the barrier, which the lake has not, in this instance, been able to force through and through. The mountains of Fishkill, continued northeastward to Quaker Hill, seemed to have resisted the pressure. But it also seems that a partial breach was made by the Ten-Mile river, a branch of the Housatonick, in the town of Amenia, Dutchess County, New-York, contiguous to Lichfield county, Connecticut. The water issuing this way reaches Long Island Sound at Stratford. Another partial breach was made by the Croton river, which rises near the Connecticut line, and empties into the Hudson at the Tappan Sea. But the lake above might have overflowed the dam, which it was unable to break, until the channels of the *Ten-Mile* and the *Croton* were worn. The rugged aspect of the mountains in North Salem almost lead one to suppose the flood of the lake pouring over Joe's Hills, rushed down their southern side, and carried along the loose and detached materials, as far as its force could convey them. Sand and stones as usual were urged to the greatest distance; moderately weighty rocks not quite so far; and the heaviest ones loitered in the rear, or concealed themselves under the water of the sound, where they annoy navigators.

It may be conjectured, that among these slow but steady operations, the strata of granite at Hellegate were broken down and torn up from their foundations, and the Archipelago of islands produced which so strongly impress the mind of the traveller as he approaches that memorable strait from the east. Some of these islands, such as Hurtleberry Island, Pea Island, the Brothers, and a number

more, have a basis of stratified rocks; while Hart Island, Miniford's Island, Riker's Island, and several others, are modern and alluvial. The tide, and storms from the N. E., have done much of this work.

I next proceed to trace the consequences of the breach through the Clove, where the Ramapough river now runs. That part of the imprisoned water escaped through this passage, is so plain an inference from the appearances, that every traveller through the pass readily and involuntarily draws it. Such a burst of rocks, stones, sand and water appears to have been driven over the region, situated along the Hackinsack, Saddle, and Passaick rivers. After sweeping along the valley lying between Bergen and Newark, it seems to have rolled up a huge pile of materials on the north side of Staten Island, and to have imparted to it a portion of its altitude, roughness and character. Another mass of these dislodged materials appears beyond the Rariton, in the form of the Neversink Hills, carried thither by the impetuosity of the flood.

The south side of Staten Island resembles Long Island. Carbonated wood, pyritical coal, and other organic remains, have frequently been discovered by digging wells. At the Narrows, where the fortifications and beacons are, several pieces of native copper were found by the labourers on the works. Has this any connexion with the copper mines near Belleville, above? Over other parts, iron ore is scattered. Has this any relation to the iron mines along the Ramapough in the Clove?

The basis of the Neversink Hills is oceanic. Upon this has been accumulated the mass of sand and stones, from the interior district. Near their summits are

detached pieces of sandstone, and some of them many feet in length, and of considerable thickness. None of it however is stratified. Has this broken sandstone any connexion with the same material at Belleville and the other adjacent quarries? Their height as found, barometrically, by the gentlemen already mentioned as associated with me on an expedition thither for the purpose, in 1816, is only two hundred and eighty-one feet above the tide-water. For the particulars I once more refer to my letter of information to the Treasury department, and to Mr. Blunt's excellent work, The North American Coast Pilot.

Near the foundation of the Neversink Hills, is a stratum of marine exuviæ, that give to Monmouth County a peculiar importance. It is a sort of calcarious powder tinctured, as is supposed, with pyrifical or vitriolic matter, and containing the remains of several animals. Among them are,

A Belemnite.
A Gryphæa.
A peculiar Oyster.

A tooth and part of the jaw of a lizard monster, or Saurian animal, resembling the famous fossil reptile of Maestricht.

There have been also discovered in the neighbouring region extending to Shrewsbury and Middletown,

A Baculite.
A thigh bone, probably of a rhinoceros.
A tooth of an elephant (see plate I. fig. 2), and in a

district so full of fossil remains, it may be expected that many more articles will be found.

That the reader may rightly comprehend the form of the monitor relick, it is figured in plate III. figure 4.

For some curious and instructive remarks on the geological constitution of New-Jersey, especially of the space between the Raritan and Delaware, I own my obligations to the Hon. John Rutherford. The report of this gentleman and his colleagues to the legislature at Trenton, on the feasibility of a canal communication between the two rivers, contains many excellent facts and observations. The one, that the Millstone river penetrates and passes the primitive ridge from the south, in a direction diametrically opposite to the course of all the other rivers on the continent, is very singular.

I come now to the enumeration of some of the probable consequences of the Hudson's breach through the Highlands in the channel where it now continues to run.

Upon the supposition that this was the fact, a great mass of materials must have been impelled, in a dismembered and confused condition to the lower district situated nearer the ocean.

The island of Manhattan, upon the southwestern extremity of which the city of New-York stands, has a basis of granite and gneiss, regularly stratified. The strata in many places are nearly vertical; that is, they decline but a few degrees from the perpendicular. Sometimes the rock of this formation breaks up with sufficient regulari-

ty to be laid in courses, for the construction of walls. The battery near the southwest castle is underlaid by such stratified rock ; though now almost entirely covered up by art in the progress of improvement. In thousands of spots over the island, their naked backs rise above the surface. Great labour and expense have been necessary for opening the streets and avenues through them. At Hellegate and Bloomingdale these rocks appear in their proper and geognostic forms; making a spectacle highly worthy the notice of all persons of taste as well as of science.

Upon this foundation of ancient stratified rock, a very different and modern deposite has been made. This is more considerable towards the middle and southwest, south, and southeast side, than at the other extremity near Kingsbridge and Haerlem. In its passage by the island, the Hudson's direction is considerably to the westward of south.

The inundation from the lake beyond the mountains has left some strong marks of its action.

To the eye of the geologist, it looks as if a portion of the overwhelming torrent, repelled by the Trap-wall at Fort Lee, changed its direction, and opened the channel of Haërlem river, filling its former estuary with the alluvial matter that at this day constitutes Haerlem flats.

Like Long Island, Staten Island, and the Neversink region near Sandy Hook, there is evidence, a little south of Bellevue, of an oceanic stratum of sand with the broken shells of clams and oysters scattered throughout it. This marine stratum, as well as the granite on which it rests,

has been overspread by the more recent alluvion now under consideration.

The alterations perpetually making by public authority, afford lessons to the naturalist, as instructive as if they had been made for his special use. While streets are opening, and hills digging down, there are the fairest opportunities of examining how the strata lay and of what they were composed.

These alluvial materials are disposed horizontally, waving in some places, and dipping a little; but convincing the beholder that they were so arranged by the action of water.

The constitution of these strata, upon which the city of New-York actually stands, is sand, gravel, rounded stones fit for paving, and loose rocks, some of them of enormous magnitude. There is a scarcity of clay in the soil; that is to say, it is not stiff enough to form bricks. At most it is but a sandy loam.

Nodules of stony matter, disclosing by their fracture petrified shells and their impressions, have been often found. During this season of 1817, such organic relicks were brought to me from Corlear's Hook, the Battery, and a place situated between the Bowery and Broadway.

Broken pieces of compact shistus, alone, and associated with quartz, have frequently been found.

The rounded rocks are sometimes six feet in diameter. In the progress of alterations made by public authority, they are daily disappearing from view. Part of them are buried in the ground; but the

greater part rent to fragments by gunpowder, and dragged away. In a few years much of the scenery I am describing will vanish, and the bustling cit will hear with wonder, or rather refuse to hear, the curious geology of the street in which he resides. They consist of rolled or rounded masses of

Schoerl rocks.
Rocks of quartz and schoerl.
Rocks of stellated asbestos.

Granite rocks, in which the ingredients are variously associated and modified.

Gneiss rocks, whose constituent parts are also differently mixed and combined.

Now, it is apparent, that there is a strong and close resemblance between these alluvial substances in New-York city, and those beyond the Highlands, and at Newburgh and Fishkill. For example, the sand, gravel, and stones are of the same quality with those near Newburgh, and are disposed in similar loose strata.

The shistose fragments occurring in New-York, exactly resemble those in the region north of the mountains.

The primitive rocks, of the kinds already enumerated, can only be considered as fragments from their parent mountains. Who can view them in any other light, than that of members torn by violence from the body to which they were once attached? In short, they may be conceived as the materials which before their disintegration and removal formed the barrier of the mountains where the Hudson now flows.

But, above all, the fossil remains in the loose and detached masses, scattered over the city of New-York, (and rapidly disappearing from sight, as houses and other buildings are erected,) resemble in every particular the fossil relicks along the Wallkill. The specimens brought to the New-York Institution by the Rev. Mr. Schaeffer, pastor of the Lutheran church, by John Macomb, Esq. Street Commissioner, and by Mr. D. Bruce, are documents of the most instructive and important nature on this subject. Had they not been found in the city of New-York, a mineralogist, on examining them, would pronounce them to be productions of the county of Orange, or of Dutchess.

As parcels of this copious deposite, on the breaking of the mountain barrier, may be reckoned the islands, with their shoals, in the bay. Governor's Island, Oyster Island, and Bedlow's Island, with Sandy Hook, and the spits and bars in its vicinity, ought all to be considered in connexion with that grand catastrophe.

Some of the minerals and fossils seem to have been left by the way. A superb specimen brought by James Smith, Esq. from Mount Pleasant, or Singsing, in Westchester county, presents marine shells of the same character and species with those already described.

To the same gentleman I am indebted for the very singular fact, that the sandstone at Nyack, in the county of Rockland, scarcely more than thirty miles north of the city, overlays a stratum of loose loam containing the bones of mammiferous quadrupeds, or land animals. Mr. Smith's polite disposition and zeal for science induced him, in 1815, to accompany me to the quarry of Mr. William Palmer, where, on breaking up the sandstone,

the bones had been disinterred. The proprietor declared his knowledge of the fact. To convince ourselves, we, and our attending friends, went into the quarry and dug out bones of land-animals with our own hands. They were in fragments; but the articulation and points of muscular insertion are evident in several of them. The specimens I brought away are now in my collection.

These relicks were not petrified; but lay scattered through a loamy bed, upon which were a stratum of sandstone, eight feet thick, and another of arable soil, four feet thick.

The place where we found them is but a few rods from the right bank of the Hudson.

Rockland county has afforded another fossil phenomenon. Eleven miles west of the spot where bones of quadrupeds lie buried under strata of sandstone, and only thirty-two north of this city, the remains of a mastodon were found in July, 1817. Mr. Edward Suffern, jun. has obligingly put the set of grinders, all that remained of the skeleton, at my disposal. Figures of one of these are given in plate II. fig. 1 and 2. They were accidentally discovered by a ditcher, who was opening a trench on his father's farm at New Antrim, in the town of Hempstead. They lay in mud, only three feet below the surface. They were large, and the enamel remarkably white and glossy. The roots were much decayed. The generous donor informed me the cavities of these teeth contained a fatty substance. None of this, however, remained when they were brought to me.

3. The breach in the vicinity of Quebec, by the river St. Lawrence.

When this opening was made by the force of the included water, the land was laid bare on both sides of that river, as far up as St. Regis, including the islands of Montreal and Jesus; and by the same operation, the land on both sides of lake Champlain would be drained as far as Ticonderoga and Whitehall. The following fossil relicks countenance this supposition.

The specimens of pectinites and other marine animals brought to me from the lime-quarries of Montreal, by Professor Andrew Ellicot, of the United States' Military Academy, at West-Point.

Specimens of a like character, filled with marine exuviæ, from the strata of calcarious carbonate at St. Regis, sent to me by the same gentleman.

Ammonites from the vicinity of Plattsburgh, brought by his excellency Governor Tompkins, incased and preserved limestone.

Pectinites, Ammonites, Corals, and shells of various kinds, observed by Bishop Kalm at Crown Point, and other places along Lake Champlain.

4 and 5. The breaches made by the Delaware and Schuylkill rivers through the lower barrier.

The alluvion at and near Philadelphia, ought to be very considerable, since two rivers have concurred to bring it down to its present location. In this respect, the site of that beautiful city deserves to be compared with that of New-York. Both stand upon an alluvial base; which rests upon a primitive bottom. Mr.

Maclure, the best authority extant, informs the public, in the new edition *of the Geology of the United States of America*, &c. just published by Abraham Small, (p. 33), that the "city of Philadelphia stands upon primitive rock, though, at the Centre-Square, thirty or forty feet of sand and gravel must be penetrated before the gneiss rock, which ascertains the formation, is found."

Dr. Amos Gregg has stated that the land where Bristol stands, is made ground, and that within no great period of time. As a confirmation of the opinion, about twenty-five feet below the surface, the earth is found to be the same with that of the adjacent marsh, to wit, a black mud. Both are nearly upon a level. At that depth, in several places, have been found large sticks or rather logs of wood, sound and uninjured by the waste of time, except about a quarter of an inch on the surface. He thought they were of pine.

At this place the geological appearances are so peculiar, that Mr. William Bartram was led to conclude, the low marsh, meadows, and ponds, situated N. W. of the borough, were once the bed or channel of the Delaware, and that the present bed of that river was a low isthmus which connected it with the firm land of New-Jersey.

The following extract from the *Picture of Philadelphia*, published by James Mease, M. D. shows the topographical character of the bottom upon which the city stands, (p. 15, 16.) The "immediate substratum of Philadelphia is a clay of various hues and degrees of tenacity mixed with more or less sand, or sand and gravel. Underneath, at various depths, from twenty to nearly forty feet, and also on the opposite shore of New-Jersey, are found a variety of vegetable remains, which evidently

appear to have been left there by the retiring waters. Hickory-nuts were found a few years since, in digging a well upwards of thirty feet below the surface; and the trunk of a sycamore (button-wood or platanus) was discovered in Seventh-street, near Mulberry-street, about forty feet below, imbedded in black mud, abounding with leaves and acorns; about sixty feet distant from that place, a bone was found; the stratum above was a tough potter's clay. In various other parts of the city, and even at the distance of several miles in the country, similar discoveries have been made. Shark's teeth are occasionally dug up many feet below the surface near Mount Holly."

The following fact is told of a fossil found in Maryland. Some men in working an iron-mine, at Bush-creek, near the head of Chesapeake Bay, found the trunk of an oak tree, thirty feet underground, fixed by its roots in its natural erect position. The wood was penetrated by the ore. The specimen of this curious transformation was exhibited in Philadelphia. (Col. Mag. v. 1. p. 268).

Alluvion of the Susquehannah.

I cannot suppress the persuasion that great deposites have been made by the impetuous stream of the Susquehannah. Spesutia island, Poole's island, and the adjacent shores, bear witness of these circumstances.

Near the end of October, 1817, charcoal and ashes were found, fifty feet below the surface, near Elkton, at the head of Chesapeake bay. The proprietor, Mr. Thomas Moore, an inhabitant of Elktow-neck, and residing four miles from the shore, was digging a well when he discovered these articles. The quantity of charred coal

and ashes raised, was six cartloads. There was also a parcel of burned brands, or pieces of wood, charred at one end, found at the same depth. These were birch and beech, and though soft, sufficiently entire to be ascertained and distinguished. On many of the pieces there were marks of edged tools, and of their having been split by human hands. These pieces of burned wood filled a corn basket, of the capacity of two bushels.

In penetrating to this depth they passed common soil, yellow gravel and stiff clay; and they found water at the very place where the charcoal, ashes and wood lay. The soil above was overgrown with ancient trees of hickory and oak.

I remember, that petrified bones, apparently of a whale, were brought from the shore of Chesapeake bay, near the place where the river Patuxent enters it, to the City of Washington, by Mr. O'Neale.

In the geographical description of the country around Baltimore, by Dr. Horace H. Hayden, there is a fact concerning organic remains. In digging a well in that part of the city east of Jones's falls, called Old-Town, a log and a nut of the black-walnut-tree, were found twenty-one feet below the present surface, in a good state of preservation.

The grinder of an elephant was dug out of the ground by the side of a marsh, in Queen Ann's county, on the eastern shore of Maryland, while opening a ditch. It differs, as Dr. Hayden observes, in some respects from the African as well as from the Asiatic elephant's grinder. The depth of this tooth is nine inches; the length of the grinding surface nine; breadth four and a half. It has

twenty-one ovoidal processes, or what Mr. Blake calls conical processes. It is considerably convex on one side, which leads to a belief that it is a grinder of the upper jaw; the convex side corresponding with the arch of the zygoma and alveolar circle. Its weight, after the loss of its roots and gelatinous matter, is more than ten pounds.

At upper Marlborough, on the Patuxent river, there is a stratum of rock of a gray shore-sand, filled with shells of an univalve mollusca, which seems to be a buccinum. The specimens I possess are very beautiful.

I possess also the moulds, in indurated clay, of that spiral shell which resembles a cork screw. In these the covering has perished, and the earthy core alone remains. Some of them have been flattened and distorted by compression.

The fossil remains in this region, bordering on the Susquehannah and the Chesapeake, afford proofs like those already stated of a deposite from inland floods since the oceanic strata were formed. There is an extensive field for further research, which the sons of science in Maryland will hasten to explore.

The effects of the breach by the Potomac river, upon the land below the Falls.

The region with which I am more particularly acquainted, is the District of Columbia. Washington, the seat of the general government, is situated in lat. 38° 53′ N. seventeen miles below the Great Falls of the Potomac, where the locks have been constructed, and about

five or six miles lower than the Little Falls above Georgetown. It is just at the head of tide-water, which rises and falls between four and five feet in the Eastern branch. Along the shore from the mouth of Rock creek to the Tiber, the land adjoining the Potomac is of considerable elevation. From the latter place to the point at which the junction takes place with the Eastern branch, the shore is more flat and low. From this plain on the south, and from the bank of the Tiber on the west, rises the Capitol Hill.

The height of this hill is more than eighty feet above tide-water, and between sixty and seventy above the adjacent low ground. Digging has shown that all the strata are horizontal; and the pebbles and stones mingled with the sand are rounded as if worn by water. This appearance is universal along the banks of the rivers and the streets.

Under this mass of alluvial materials organic remains exist. They lie in a stratum of muddy clay. Trunks and branches of trees are found in abundance at the depth of fifty-four feet under the surface of Capitol Hill. Frequently the wood is blackened so as to resemble coal, and is mingled with pyrites.

Forty-five feet below the surface of the lower ground, near the Eastern branch, a bough of sound and seasoned black-walnut was found on digging a well. A bone, apparently a rib of some very large, or elephantine animal, was dug out of the bank of the Potomac, and exhibited for a show. Shark's teeth, or glosso-petræ, are often raised on digging wells, further down the river, as at Diggas's point, for example.

This will show that there is a marine alluvion; and that a fresh-water or inland alluvion has been superinduced.

The Alluvion brought down by James's River.

In the neighbourhood of this stream there is an abundance of organic remains. They are partly derelictions of the ocean, and partly accretions by the floods.

On the authority of William Wirt, Esq. it is stated, that as far west as the Blue Ridge, marine shells and other exuviæ of the ocean have been found, showing that the region was once emerged in the deep.

Mr. Chevallié brought me, from Richmond, entire triangular teeth, apparently of sharks, and pieces of bones, probably of whales, dug from the depth of between sixty and one hundred feet, in the city of Richmond. Above these, in penetrating the earth, were found bark and wood, and the thigh bone of a small quadruped, probably a squirrel. All these are now in my cellection, at the College.

It has been repeatedly affirmed, and on the examination of the distinguished gentleman quoted in the paragraph before the last, that in the neighbourhood of Williamsburgh, in 1802, a considerable portion of a whale's skeleton was discovered. It was about four or five feet under ground; two miles distant from the shore of James's river, and fifty from the Atlantic ocean. Among other parts were fragments of the ribs, and all the vertebræ regularly arranged, and very little impaired as to its figure.

So, on the bank of York river, the same observer, while walking on the sand beach, noticed, in the high cliff or bank above him, strata of sea shells not yet decomposed, of the same kind as those which lay on the beach under his feet, interposed with strata of earth, showing at once the comparatively recent retreat of the water, and the subsequent action of the inland floods, and of the winds, to accumulate soil in that place.

Benjamin Henry Latrobe, Esq. has surveyed the maritime parts of Virginia, from Aquia creek to Cape Henry, with the eye and the mind of a geologist. His publication on the sand hills and sand quarries in that region, abound with interesting fact and argument. He found carbonated wood with loose stone to underlay the strata of Potomac-sandstone. The wood mixed with the stone near James's river, appeared to him less carbonated than on the Potomac and Rappahannock. In the vicinity of the latter river, at Mansfield below Fredericksburg, the largest mass of timber he had seen, lies below the freestone.

The Virginia sandstone does not merely rest upon vegetable relicks. It is penetrated by them. To the component parts of the stone, such as sand, clay, pebbles, pyrites, nodules of iron-ore, oxyd of iron and native alum, are added organic remains. Wood of all sizes, from the trunks and branches of trees to small twigs, ramifies throughout the strata. Sometimes it is entirely carboned; or the wood is carbonated and the bark in a fibrous state, so as to have a net-like appearance, with a considerable degree of tenacity; or the bark is fibrous, and the wood in a state quite friable; or the wood replaced by a pyrites which undergoes decomposition by exposure to the atmosphere; and some other forms.

While treating of the maritime borders of Virginia, let me not forget to mention the remains of a mammoth found on the bank of York river, in 1811, about six miles east of Williamsburgh. When discovered, they lay on a marsh-mud, or a few feet within it, surrounded by roots of cypress trees penetrating the earth where the bones were found. Those roots were evidently the remains of such as had been shot forth by trees growing in the ground, now removed by water. The difference between the present level, where the bones and roots are, and the top of the adjacent bank, is more than twenty feet.

I received these facts from that reverend prelate, bishop James Madison, then president of William and Mary College. He visited the place, and examined into every thing relative to the discovery, with his accustomed accuracy. (See further particulars in Med. Repository, vol. xv. p. 388, 390.) It will be there found, that the parts of the skeleton raised, were the ossa innominata; a femur or thigh bone; two vertebræ or joints of the back; two ribs almost entire; two tusks in tolerable preservation; seven teeth, all of them grinders, and four of them fixed in their sockets, which seemed to be part of the lower jaw.—The weight of the largest tooth was 7 1-4lb.; of the smaller, from 3 to 4lb.

Other Fossil Remains in the United States.

Rhode Island.

Rhode Island contains a stratum of coal. It burns with little or no flame, and is somewhat difficult to kindle; but makes an intensely hot fire. It is associated frequently with quartz, and sometimes with asbestos crystallized. It does not emit any kind of offensive

vapour; and is therefore as good for brewers and maltsters as Kilkenny coal. Over this coal lies a stratum of thick coarse slate, containing ferns of a very large size. They appear to have been petrified, inasmuch as their substance seems to have been there. They cross each other, throughout the several laminæ, in all directions. Dr. Case's publications afford much information concerning the inflammable materials covered by this roof of capillary plants. The specimens I possess are very distinct.

North Carolina.

At a place called Fishing creek, 150 miles from the sea coast, and almost four from Tarborough, in digging some little depth, they found a part of the skeleton of a whale, with sea shells in abundance. In the same place, in digging a well, at the depth of almost thirty-five feet, they found a cypress stump, with chips about and upon it, and an iron hatchet or wedge sticking into it. The skeleton of another whale, together with a petrified portion of a shark's jaw with teeth, has been found at a place called Williamstown, more than 100 miles from the sea coast.

About a year ago, the skeleton of a huge animal was found on the bank of the Meherrin river, near Murfreesborough. It was dug out of a hill, distant sixty miles from the ocean. Capt. Neville and Dr. Fowler, who visited the spot, gathered the scattered vertebræ which the negroes had thrown out, and laid them in a row thirty-six feet in length. If to this the head and tail be added, the creature must have been perhaps fifty feet or more in length. The former of these gentlemen enriched my collection with two of the teeth and a

joint of the back bone that he brought away. The teeth weigh sixteen ounces each. They are covered with an ash-coloured enamel, except at the roots where they were fastened in the jaws. Their figure is triangular, the sides towards the apex measuring six inches each, and the base four inches and a half across. The joint of the back is not cartilaginous, but actually bony. It is in some degree petrified, and weighs twelve pounds and a half. It, in all likelihood, belonged to a shark or a sea-serpent.

The Rev. James Hall, a missionary from the general assembly of the presbyterian church and the synod of the Carolinas, to the Mississippi territory, published at Salsbury, in North Carolina, a short account of the more memorable observations he made during his journey. He affirms, that a bed of clam and oyster-shells, as fair as ever lay on the shore of the Atlantic, is to be seen in an old field in the Chicasaw country (p. 58). In the Mississippi territory he saw freestone, and a yellow calcarious earth, which is apparently a concretion of shells. He observes, that it burns into good lime, and that the land is destitute of stones.

South Carolina.

Very remarkable organic remains have been discovered in South Carolina. I refer with pleasure to Governor John Drayton's *View of that State as respects her natural and civil concerns*, for the full description illustrated by an engraving of the teeth and bones of elephantine animals, dug out of Biggin swamp, in 1794, by Colonel Senf, near the head of the West Branch of Cooper river, about eight or nine feet under ground; as also for the distinct account he has given of the stratum of enor-

mous oyster-shells, extending from Nelson's ferry on the Santee, southwest to the Three Runs on the Savannah river.

Georgia.

From the information of General David Meriweather, I learn valuable particulars concerning a remarkable body of sea shells, now existing in the internal parts of Georgia. Of a number of them I possess specimens.

"The shell banks, as they are termed, make their first appearance on the south bank of Savannah river, near the place called *White Bluff*, about a hundred miles on a straight line from the sea shore, and run about southwest. They are not one entire ridge, but the ground is higher for about six or eight miles in width than it is above or below. On this ridge the shells make their appearance, in many places near the surface, and in others deeper. Not only the *oyster-shell* is found, but *clam* shells and a *scalloped* shell nearly similar to the clam shell. Some of them are large, and appear to be entire; others are cemented together. I think I have seen some of them large enough to contain the foot of a common man. I have seen the shells in different parts of the ridge, for the space of forty miles. They are made use of for lime, but are not supposed to afford a product so good as the common shell lime. I have been informed, that further to the southwest, and a little above the direct course, they get a congeries of shells which is in a rocky form, and affords a better cement.

"And what is more extraordinary, at some distance above that, there are several quarries of a kind of silecious stone, which has a number of all kinds of shells

intermingled and dispersed throughout it. These are petrified and as hard as flint." These are wrought into millstones, and are considered as a good substitute for French burhs.

In a spring near the high shoals of Apalachy, are found many echenites of a flat form, rather larger than a Spanish dollar. On the upper side are five radial bars of four rays each. The upper side is rather convex, and the lower, concave. They are converted to flint, and are a species of the scutella family.

Florida.

Ellicot's Journal of the occurrences during the expedition for determining the boundary of the United States and his most Catholic Majesty, between the years 1796 and 1800, contains valuable information on the fossils of the Apalachy, Chatahouche, and Flint Rivers. Vast strata of limestone abound. It seems to be the prevailing basis of the soil, and almost the sole ingredient of the rocks, islands, and keys quite round Cape Florida. It is composed in many places of broken shells, and filled with petrifactions.

Louisiana.

The following extract of a Letter received from William Darby, Esq. author of the valuable Map and Description of Louisiana, contains the information collected by that intelligent gentleman of a Fossil Elephant found on the right bank of the lower Mississippi.

In the month of October, 1804, I first visited the southwest part of the now state of Louisiana, Ope-

lousas, and when in that country, learned the following facts:

About the year 1797, Mr. Martin Durald, commandant of Atacapas, addressed a letter to the late William Dunbar, of Natchez, to the following effect:—That when the French first came into the country, now Atacapas and Opelousas, they found a watercourse, to which the native savages gave a name, that in their language was equivalent to "Carion Cro" in French. Mr. Durald demanded of the Indians, for what reason they gave the name of Carion Cro to that bayou; they replied, that in the days of their fathers, a large animal came there and died, and that so many carion crows assembled to devour the carcass, that ever afterwards the creek (bayou) received the name of Carion Cro. Mr. Durald further states, that he, after his establishment in Atacapas, instituted an inquiry, and found that part of the bones of the large animal spoken of by the Indians had been recently discovered, and were to be seen on bayou Carion Cro.

Mr. Durald's communication on the fossil bones at Opelousas, west of the Mississippi, is printed in the Philosophical Transactions of Philadelphia, vol. vi. p. 55. In digging wells there, various bones have been found, such as a human skull, thirty-five feet deep; pottery of the natives; oyster shells, twenty-two feet deep; a goat's horn; enormous bones, supposed to be those of the elephant; teeth and jaw bones of the same. There was a cart load or more of these huge remains in one place, on the farm of Mr. Nerat, as Mr. Dunbar relates.

I myself visited Opelousas in October, 1804, and while there, learned from Dr. Raphael Smith, of that place,

who resided within two miles of Carion Cro, that within a few days before my arrival, some very large bones had been disinterred. I went with Dr. Smith to the spot, and assisted in digging out of the earth a jaw bone, answering exactly to your Plate VIII. Fig. 2.

I measured the tooth, and found it four inches over the enamel, and about one foot in depth. It contained transverse lines, as represented in your Fig. 2. Plate VI. The fragments of this tooth were sent to Dr. Garret E. Pendergrast, of Natchez, who remitted them to Dr. Wistar, of Philadelphia, in whose possession they now remain.

It is a curious and interesting fact, that the spot where the savages reported from tradition that the *large animal* died, was within one mile of the very place where Dr. Smith and myself found the fossil tooth. The surface of the ground was a loose loam, which had been formed by accretion of soil in the lapse of ages. The tooth had been opened to-day by a drain from the Prairie. The enamel was perfectly entire, but the other parts had been changed to a carbonate of lime.

Mississippi.

The earthquakes which shook North America during the years 1811, 12 and 13, were accompanied, among other occurrences, with an ejection of warm water, sand, and coal in the region adjoining New Madrid, near the Mississippi. Some of this volcanic coal was brought to me at Washington City, and in May, 1812, I made some experiments upon it, which led me to a belief of its vegetable origin. I found it very inflammable. It consumed with a bright and vivid blaze. A copious smoke was

emitted, whose smell was not at all sulphureous, but bituminous in a high degree. Taken out of the fire in its ignited and burning state, it did not go out, but continued to burn until it was consumed. When blowed upon, instead of being deadened by the blast, it became brighter, and the ashes turned vegetable blue to green, showing its alkaline quality.

Alabama.

The fossil specimens sent me by Mr. Magoffin from the neighbourhood of St. Stephen's, on the Tombigbee river, are highly interesting. They consist of the shells of bivalve molluscas, and of sea-urchins and radiary animals. Some of these are distinct and in their proper forms; others compacted into limestone, with many of their lineaments remaining; and others changing and changed to chalk.

Fifteen or twenty feet below the surface is a stratum where wood is found, of different kinds, partially decayed. Beneath this and a concomitant body of clay and soft limestone, is a substance resembling the grass on the margin of the ocean, accompanied by numberless marine shells. The water from this, on first being taken up, smells like bilge-water.

Missouri.

What shall we think of the genus and species of that petrified skeleton of a very large fish, seen in the Sioux country, up the Missouri, by Patrick Gass? In his Journal to the Pacific ocean with Messrs. Lewis and Clark, in 1804—6, he relates that it was forty-five feet long, and lay on the top of a high cliff. He mentions also a petri-

fied log of wood, out of which whetstones and hones could be made, in the Mandane region.

This outline of North American geology is, I am sensible, very imperfect. Further observations will be required to fill up the picture and finish it by proper colouring. These, as they occur, may be arranged in their places, and contribute to the excellence and beauty of the piece.

With the acquisition of facts from a wider field, the composition may be enlarged. Things which lie beyond the limits of my survey will be introduced. In process of time, it may be expected, that the whole scenery between the Caribbean and the Frozen seas, and between the Atlantic and the Pacific oceans, will be introduced.

When this object shall be accomplished, our contribution to the geology of the globe will be respectable. It may be added to the intelligence concerning South America, laid before the learned world by Baron Humboldt and others.

Conclusion.

I have forborne to refer any of these great changes to epochs in time. Chronological dates and historical records do not reach far enough back to answer all the purpose. Viewing the face of the earth as I do, some conception may nevertheless be entertained of the synchronism and succession of the respective formations. Let us take them in the inverse order from that which was stated in the introduction to this Essay.

1. Modern depositions from the briny ocean. These, as they consist of wearing away some places and adding to others, are in daily operation. There can be no doubt that such changes have always been going on since our planet received its present configuration. Many of them are subsequent to the commencement of animal and vegetable life.

2. Depositions from fresh water are also constantly making. The showers of rain, the currents of rivers, the trickling of springs, and the bursting of lakes, are all instrumental in producing alterations of this kind. From the nature of these productions they are deeply connected with beings that have enjoyed life, as we know from the vast number and variety of their fossil remains. I consider these formations as subsequent to the preceding in their origin and commencement, but coetaneous ever since.

3. Proceeding further back, the inland seas of salt water present themselves. In North America they have lost their briny quality, and become fresh lakes; while, in Asia, there are numerous instances of inland salt seas to this day. The subsidence of the North American lakes in the first instance, and their conversion from saltness to freshness in the second, are occurrences of the most interesting nature. They have given a peculiarity and distinctness of character to our geology, which naturalists among us will learn to appreciate.

4. After exploring the extensive formations of this kind in North America, we are carried to the most ancient foundation, beyond which our inquiries are incapable of penetrating. These materials probably constitute the solid body or nucleus of the globe, according

to the original arrangement, when the confusion of chaos was reduced to order, and at the command of their Creator, the waters under the heaven were gathered together into one place, and the dry land appeared.

That water was the principal agent in all these operations, there can be no doubt.

But there was unquestionably another agent, of a most powerful character, and that was fire. This is the cause that produces volcanoes, or burning mountains, with their explosions, eructations and convulsions. I have not, however, dwelt upon them, because there are none of them within the limits of my survey.

Thus, water and fire acting separately, by what is called the moist way and the dry way, have wrought and are yet working memorable effects on the superficial crust or external covering of our earth. Jointly, or acting in connexion, their operation is tremendous.

Difficulties have been raised concerning the subsidence of the primitive ocean. I have published, nine years ago, my opinion that it must necessarily have diminished very considerably, for several reasons:—1. A great draught must have been made upon it to form the atmosphere. 2. Another, and a very great portion of it, entered into the constitution of crystals, where it is solidified and embodied. 3. The bodies of vegetables absorb and confine a portion of it. 4. The bodies of animals consolidate or contain much more.

Geologists have, nevertheless, called in the aid of other causes.

The approach or the stroke of a comet has been supposed, by Count Buffon, capable of overturning the order of things, and of introducing into the system full as much confusion as the strata, and their organic remains exhibit to us.

Whether this was the fact or not, is impossible for us to know. Mr. Kirwan has given weighty reasons for his belief, that the globe's surface has been, at some remote period, most violently assailed by a mighty flood from the southeast. Tearing up and bearing away the looser materials of the southern hemisphere, it has brought a great body of them to the northern, and impressed upon the Capes of Good-Hope, of Horn, of Van Diemen's Land, and other promontories, the marks of its overwhelming force.

This opinion corresponds very well with the geological features of the United States. What agent so capable or so likely to wash up the sand and other materials into such ridges as our mountains present? The impulse of an ocean upturned from its bed, rolling impetuously over the land, and carrying every thing before it, may be supposed competent to the accomplishment of such a work.

Attempts have been made to explain this rush of waters, and concomitant events, by supposing that our planet has changed its axis. This hypothesis has something plausible to the geologist, and seems to help him out of many difficulties. It places the poles and the equator of ancient days in situations very different from those they occupy at present. Regions then cold are now warm, and districts heretofore bound by frost, are at this day cheered or parched by heat.

I was desirous to know how such a projection of the sphere would appear. At my request Mr. Darby executed a map whose equator and axis are removed forty-five degrees from the present equinoctial line and poles. By fixing one pole to the northwest of the Sandwich Islands, and the other to the southward of St. Helena, the equator crossing the isthmus of Darien, and touching the east end of Cuba, runs over the Atlantic ocean to the eastward of Bermuda, and all the United States lie between it and the tropic. The continuation of the equator passes through Ireland, England, Holland, Germany, Poland, touches the northern shore of the Black Sea, and brings all Europe between the tropics.

From that track the equator may be supposed to have been moved to the place it now occupies, producing a corresponding action in the physical character of the globe, and on the life of its plants and animals.

This notion may be said by critics to be unfounded and visionary. The reader will remember it is not offered as a fact, but as a speculation. Visions, when they are known to be such, are frequently amusing, and never mischievous. It is only when they are mistaken for realities that they mislead the understanding.

[illegible]

APPENDIX.

LEIBNITZ'S PROTOGÆA.

MY learned correspondent, Fr. Adr. Vanderkemp, of Oldenbamerald, New-York, has favoured me with a communication too important to be withheld from the public eye.

"I send you enclosed the outlines of Leibnitz's Protogæa, published in 1749, with a Preliminary Dissertation of C. L. Scheidius. Gottingen. 1749.—Inserted in Leibnitz's Works, the splendid edition of Lud. Dutens, in vi. vols. 4to. Geneva. 1768.—By de Tournes, tom. ii. pag. 181. The Preliminary Dissertation of Scheidius is continued till page 199; the Protogæa from page 199 —241.

§ 1. Introitus.
§ 2. Globus terræ regulari primum forma fuit, et ex *liquido* induruit, motrix caussa lux sive ignis.
§ 3. Distinctior de globi terrei creatione sententia, et de basi illius.
§ 4. Origo aquæ marinæ et fluviaticæ; lapidum item et diversorum terræ stratorum.
§ 5. Plurimæ globi nostri mutationes post primam creationem ex variis caussis.

§ 6. Unde fuerit aqua, quæ terram obtegit, et quo devenerit? nec non de variis diluvii caussis.
§ 7. De Bructero monte, et fontium origine.
§ 8. Metallorum in terra situs, venarumque descriptio et explicatio.
§ 9. Mineralium generationem Chemia illustrat.
§ 10. Recensentur productiones laboratoriis et fodinis communes.
§ 11. Gemmarum generatio et naturalis et artificialis est.
§ 12. Sublimationes naturales. Ammoniaci præparatio.
§ 13. Argentum et aurum aliaque metalla, quæ statim sua sunt, vi ignis prodiere in venis.
§ 14. Formas quædam accipiunt a motu aquarum, ut rotunda inter lapides et metalla.
§ 15. Quædam in aquis concrescunt.
§ 16. Tophaceus lapis a guttis cadentibus. De Stalactite antri Baumaniani, de cavitatibus ingemmatis saxorum, et de cavernis.
§ 17. Quædam a caloris et aquæ conjunctione oriuntur.
§ 18. Piscium variorum formæ in ardesia unde provenerint?
§ 19. Ignem inesse globo nostro motus terræ, Vulcani, pumices, bitumen, et alia ostendunt.
§ 20. Pisces in ardesia ex veris expressos lusus naturæ non esse ostenditur.
§ 21. De variis terræ stratis, eorum situ, et de origine salium, aquarumque salsarum.
§ 22. Montium et collium origo partim ex aquæ materiem molliorem secum abripientis defluxu, partim ex ventorum vi et terræ motibus.
§ 23. Conchylia marina in nostra regione et alibi passim inveniuntur.
§ 24. Varia conchyliorum genera mirè permista, in saxo et glarea non esse nata, et forma non mutata et situs ipse ostendit.

§ 25. Conchylia et ossa animalium marinorum, quæ effodiuntur, examinânari et resolvi possunt æquè ac verorum animalium partes.

§ 26. Antiquissimis temporibus maria vicina habuerunt animalia et conchylia, quæ jam ibi non inveniuntur.

§ 27. Glossopetræ, baculi *S. Pauli* et serpentes Melitenses, lapides Judaici, Asteriæ, Trochitæ et Entrochi, &c. sunt dentes, testæ, exuviæ et ossicula animalium marinorum, non verò lusus naturæ.

§ 28. Huc tamen non pertinent polygonorum figuræ in Crystalliis aliisque rebus; nec ea, quæ in saxis præoccupata imaginatio solummodo videt.

§ 29. Exploditur ignava quorundam solertia, quæ ludicra imaginationis vi quicquid vult in lapidibus figuratis deprehendit, aliaque a veritate aliena comminiscitur.

§ 30. Ubi Glossopetræ Luneburgenses inveniantur?

§ 31. Glossopetræ sunt dentes Carchariarum.

§ 32. Usus Glossopetrarum medicus illustratur.

§ 33. De Belemnitis, Osteocolla, Corallio, Strombitis, Conchytis, Trochitis, Entrochis, Ebore fossili.

§ 34. De ossibus, maxillis, craniis et dentibus minoribus et majoribus, quæ in antro Baumanniano, et alibi etiam apud nos inveniuntur.

§ 35. De cornu Monocerotis, et ingenti animali Quedlinburgi effosso.

§ 36. Descriptio antri Scharzfeldensis et ossium in eo repertorum.

§ 37. Descriptio antri Baumanniani et in eo contentorum.

§ 38. De Succini natura, et quod etiam in nostris terris reperiatur.

§ 39. De mutationibus terrarum per flumina, et de ruinarum ingentium apud nos vestigiis.

§ 40. Tisurgis prope Mindam montes perrupisse videtur. Ad hanc usque urbem olim paludes ab Oceano irrigui pertigisse dicuntur.

§ 41. Ubi nunc Venetiarum et Principum Estensium regiones, ibi antiquissimis temporibus mare et paludes fuere.
§ 42. Fontium Mutinensium miraculum exponitur.
§ 43. Caussa horum fontium proditur.
§ 44. Descriptio stratorum terræ soli Rostorpiensis prope Goettingam, Mutinensi aliquo modo similis.
§ 45. De obrutis terra arboribus, et fossili ligno.
§ 46. De Torfa ejusque origine.
§ 47. Singularis de arboribus terra obrutis observatio.
§ 48. Enumeratio stratorum terræ Amstelodami in putei fossione observatorum."

This learned and curious memoir is embellished by many figures, contained in twelve plates.

Leibnitz confesses himself a believer in the extensive operation of fire upon this globe. "I believe," he writes in his fifth letter to Mr. Bourguet, tom. vi. epist. 5. p. 213, "that our globe has been one day in a state like that of a burning mountain; and it was then that the minerals which are discovered in these times, and that are capable of being imitated in our furnaces, were formed."—"Rocks, which may be called the bones of the earth, are the *scoriæ*, or vitrification of this ancient fusion; sand is only the glass of this fusion, pulverized by motion; sea water is but an oleum per deliquium, produced by cooling, after the calcination. Thus the three most extensive materials on the globe's surface (the sea, rocks and sand) are naturally explained by fire, while it is not easy to explain them by any other hypothesis."

CONFIGURATION OF THE COUNTRY LYING SOUTH OF LAKE ERIE.

I own my obligation to Professor Chester Dewey, of Williams' College, Massachusetts, for the following intelligence on the natural formation of the region situated to the southward of lake Erie.

Almost all the distance from Buffalo to the head of lake Erie, there is a regular swell of land, generally about five miles from the shore, everywhere presenting to the observing traveller, sufficient evidence of its having formerly been the south boundary of the lake. The land south of this ridge is generally lower for many miles —in some places it is nearly forty miles a dead-level, except when it is interrupted by the channels or beds of creeks, which are generally deep, with almost perpendicular banks. The land on the north side of the ridge gradually descends to the north about one mile generally, where is a *second,* or what we call the *north, ridge.* This is not so high nor so interrupted by mounds of sand as the south ridge. The distance from this to the lake is about four miles, and the land a little descending towards the lake. Though the present lake-shore appears to have been fixed for centuries, probably the southern ridge was once the shore; and for the following reasons: 'The south ridge is composed of the same materials as the present shore. I have carefully viewed it from Coneaut creek to Grand river, a distance of about 45 miles. This day I have been viewing a newly dug well in the town of Wrightsburgh. From the top of the ground, the first three feet is a sandy loam; then a coarse gravel; and then a layer of small stones of the same kind which we find on the present lake-shore. These three layers

make about five feet. Beneath these are successive strata of the same kind to the bottom of the well, which is about twenty feet from the surface. At the bottom of the well, in the coarse gravel, and in a spring or rather subterranean brook, there was found a piece of (apparently) bass wood, between two and three feet long, and two or three inches in diameter. It was evidently a limb of a trunk which is now buried in the gravel and pebbles below—its direction was perpendicular, and its texture so little impaired, that it was with difficulty broken off. Lobster-shells, cockle-shells, and clam-shells, of the same appearance are found this depth from the surface, as are now found on the lake-shore. My informant describes the remains of a well-built fort, with its trench and mound, which has never been examined, but which can be given you at another time if it be of any importance to you: as also the huge human bones, which have been discovered, with some articles of stone, lead, and sometimes brass, buried with them.

In support of the above, it is added, that all these monuments are found *either on* or always *south* of the south ridge. This is sufficient proof that these fortifications were all built before the recession of the waters of the lake to the north. All these bones are found *only on* or *south* of the ridge. The land is higher on the south ridge than for a considerable distance to the south of it. The waters once inundated the land for many miles to the south; but probably by the constant breaking of the surf of the lake in the shallow waters, this south ridge was formed. When the surface of the lake was lowered, (which probably was occasioned by the breaking away of the earth at Niagara,) the creeks broke through the mound of sand or gravel, and thus began their present beds. The north ridge does not seem to

have been the boundary of the lake for any length of time; and it really seems, from many accounts, that the water of the Niagara once run off to the southward.

CLASSIFICATION OF MARINE RELICKS.

I insert, on account of its peculiar importance, the following classification of the fossil shells of the United States, by my friend John G. Bogert, Esq.

Pectinite, Arca, Glycemeris, Anomia Vitrea, Ostræa Fascinata, Terebratulites.

These specimens I chiseled out of the summit of a high limestone hill, in the County of Columbia, about 300 feet above the *surface* of the Hudson river, and distant four miles from the river, and 130 from New-York.

The limestone in this neighbourhood, at that distance above the level of the river, abounds with specimens of this description, and extends along the edge of the summit several miles, and not more than about five feet in breadth on the southeasterly side; none appearing on the northwest side near the Hudson.

That part of the hill from which I procured these specimens, presents a perpendicular of about 80 feet from its base; although from the base of the perpendicular to the stream or river below, there appears to be a descent of at least 70 feet.

If we take a view of this tract of country, extending from within four miles of the Hudson to Hillsdale on the Taconick mountains, in the State of Massachusetts, where I found similar specimens; a geological mind cannot be

otherwise impressed, than that this region has, at some very remote period, been covered with water, as the country generally is alluvial. Upon examination of a great part of this country, I found the course of the water, directed towards the Hudson, falling in many places over high precipices, and the rocks very much water worn. On the easterly side of this range of mountains, which divides the state of Massachusetts from New-York, the water empties into the Sound or East river.

Terebratulite.

Gaultieri, in his book, has made a particular *genus* for the Terebratulites, and calls them Terebratula. Linnæus calls them Anomia.

Davila ranks them as a genus of his first family of Ostrea. The break on the top of the under valve is perforated, and rises curved upon the upper valve; the hinge is inarticulate.

The *second species* of this family is multarticulate; the hinge lying on a long straight line, and set with teeth like the arc shell.

The specimens I have, are from the Ohio falls, Black river, Jefferson, Ontario, Oneida, Columbia, Rockland, and Orange Counties, State of New-York.

These remains are rarely found recent, and differ much in their external figure; some are globular, and others elongated.

Arca Noë and Arca Tortuosa.

These specimens I procured from the Wallkill, Orange County, State of New-York; they are imbedded in in-

durated clay, and are not petrified, having the shells complete, and in some instances the impressions only remain, the shell having been decomposed.

The arc shell is found in the Mediterranean and the West-Indies, and not on our coast. I have compared them with the recent shells in my cabinet from the Mediterranean, and they correspond in external figure.

It is worthy of remark, that almost all shells imbedded in clay, are *not petrified;* but indurated; having the appearance of having been submitted to the action of fire, or calcined; and are properly denominated *Conservata.*

Pectinite.

A variety called by Linnæus *Nodosa,* very large, 5 to 6 inches in diameter, with the Tintinnabulum attached in considerable number to the surface, of about an inch in length; these are converted into sandstone, and found in James's river, State of Virginia; these are generally equivalve; the hinge lies on a straight line, like the Escallop, but set with several parallel and straight ridges, and furrows.

I have specimens also from the Counties of Columbia, Rockland, West Chester, and New-York. Those from Columbia and West Chester are imbedded in carbonate of lime; those from Rockland and New-York, in clay.

The mass of Pectinites I found on a mountain in Rockland, are much water-worn externally. Those found on the island of New-York, were discovered near the State Prison in digging down a hill.

I have also a singular aggregated mass of shells, com-

pletely converted into silex, known by the name of *horse-foot*, found on lot No. 69, Cayuga reservation, and presented me by D. Clinton, Esq. This specimen has never been described by any writer to my knowledge.

Serpulite.

A fragment of a Serpula, if extended upon a straight line, would measure about 10 inches; this is a carbonate of lime, and was found in Coeyman's patent, near Albany.

Orthocerite.

First Species.—From seven to eight inches in length, and one and a quarter inch to two in diameter at the base; straight, and not turbinated; tapering from the broad end to a sharp pointed top, like a straight horn, (from whence its name.) They are chambered from bottom to top, and have a Siphunculus or pipe of Concammeration from chamber to chamber—pipe central.

These specimens I obtained from Sullivan County, New-York. In your valuable collection you have several very distinct and well marked, which I believe are from Jefferson—animal extinct.

Linnæus ranks them in his system as Nautilus Orthocera.

They are generally casts of stone or replacements of sparry matter; sometimes fragments of shells may be seen on them.

Second Species.—Lituus. This exactly resembles a bishop's crozier in shape, has a long stem, cylindrical—one end whereof has a spiral turn; this shell is soft and easily fractured.

Third Species.—Turbo Polythalamus—five concamerations. This shell has never been found, except fossil, and in that state only one species has been known to me. It is turbinated or spiral, of a lengthened shape, like a buccinum, is concamerated, and the diaphragenus are jogged like the Ammonite.

B elemnite.

Those in my cabinet are from James's river, Virginia, and Monmouth County, New-Jersey. From Monmouth County, they are found in marl pitts, near Sandy-Hook, and measure from three to five inches in length, having a base of half an inch, lengthened to a sharp point, concamerated.—Linnæus classes them with Nautuli.

Gryphite.

I have some specimens from New-Jersey and Virginia; there are several varieties; some are grooved, and others have a plain surface; some are flattened, and others almost globular, having the apex conflected. Found in marl.—This animal is extinct in this country, as also in Europe.

In addition to the above described specimens, I have also Corallites, Encrinites, Entrochites, Echinites, Chamites, Cardites, &c. principally found in the State of New-York.

In addition to the list or catalogue of organic remains, of which I have endeavoured to give some account, permit me to make one or two remarks. As there is a variety of opinions among geologists on the subject of the formation of Obsidian (although not exactly belonging to your book on the geology of North America), I beg leave to mention, that Dr. Barton, of Philadelphia, pre-

vious to his departure for Europe, showed me a beautiful specimen of obsidian, belonging to his Mineralogical cabinet, with a complete *Echinite* imbedded in it;—this specimen is in a state of conservata, and not calcined. This is a curious fact, as it offers an objection to a generally received opinion, that obsidian is of volcanic origin; and if it was so, the calcarious matter must have been decomposed.

I would also make another observation with respect to an opinion of Cuvier. He says that crystallized marbles never cover shelly strata. Perhaps this may be the case in that part of Europe which has been examined by him; but I have discovered granular foliated limestone, perfectly crystallized, in the County of Columbia, in the neighbourhood of Hudson, containing pectinites, anomites, terebratulites, &c. specimens of which I have.

There have been some inquiries made with respect to the rocks called the Pallisadoes, opposite Mount Pleasant, on the Hudson river. On examination, I found the lower stratum running under the river, composed of a beautiful red granite, and the superincumbent matter consisting of a species of basalt, of the trap family. This mass of rock takes a westerly and northwesterly direction towards the falls of Passaick, and there becomes the trap of the secondary formation; in which I found several pieces of agate, imbedded in a similar manner to some specimens I have received from Leo. M'Nally, Esq. of Dublin, which he obtained near the Giant's Causeway.

CONTENTS.

1. Introductory Observations 321
2. The Original Saltness of the North American Lakes 327
3. The Barriers which probably restrained the waters, in some parts of North America, after the ancient ocean had retired 332

I. THE INNER OR UPPER BARRIER. ib.

Breaches of this Barrier 334
1. At the northeast extremity of Lake Ontario .... ib.
2. ——— Northern extremity of Lake George 335
3. By the Hudson River, at Hadley .... ib.
4. ——— Mohawk River, at the Upper Falls 336
5. ——— Delaware, above Easton 337
6. ——— Lehigh, above Bethlehem .... ib.
7. ——— Schuylkill, through the Blue Ridge 338
8. ——— Susquehannah, through the same .... ib.
9. ——— Potomac and Shenandoah 339
10. By James's River 344
11. By the Ohio and Mississippi .... ib.

Enumeration of certain Organic Remains found within the limits herein delineated.

A. Marine Productions 345
Oysters .... ib.
Scallops 346
Pectinites .... ib.

PAGE
Orthocerites 346
Madrepores.. 347
Terebrums 348
Clams.. ib.
Cockles.. ib.
Fish Banks, south of Lake Ontario 349
Fossils along the Illinois.............................. 350
Fossils in the state of Ohio.......................... ib.

LAND PRODUCTIONS.

Ferns .... ib.
Palms.. ib.

CHANGES WROUGHT BY THE BREACHES OF THE INNER BARRIER.

The Falls in Black River.............................. 351
Onondago River.......................... ib.
Salmon River.......................... ib.
Seneca River.......................... ib.
Genesee River.......................... ib.
Niagara River .... ib.
Its Channel, as worn away above the cataract 352
Its Channel, as torn away below...................... 357
The Falls of Ohio...................................... 360
The Falls of Mississippi.............................. ib.

B. FRESH WATER PRODUCTIONS.

Bones at the Licks in Kentucky.............................. 361
Of Mastodons.. 362
Elephants.. ib.
Bisons .... ib.
Mastodon in Indiana.............................. 363
Pennsylvania .... ib.
Chemung, N. Y.......................... ib.
Ohio 364

PAGE

II. THE OUTER OR LOWER BARRIER.

Breaches in this Barrier.
1. Connecticut River 364
Impressions of Fossil Fish 365
2. Hudson River; by a branch of the Housatonick; by the present channel; by the Clove through which the Ramapaugh yet runs .... ib.
3. St. Lawrence River, near Quebec 390
4. Delaware River, below Easton 391
5. Schuylkill, below Reading .... ib.
6. Susquehannah, below Swetara 393
7. Potomac, below Harper's Ferry 395
Salt water Fossils, left bare 396
Fresh water deposites .... ib.
8. James's River Alluvion 397

C. Other Fossil Remains not comprehended within the foregoing limits and descriptions.

Petrified Ferns and Capillary Plants in Rhode Island 399
Teeth and Bone of (probably) a Sea-serpent, in North Carolina 400
Oyster-shells and Elephantine Bones, in South Carolina 401
Marine shells and Echini, in Georgia 402
The like in Florida 403
Louisiana 404
Mississippi 405
Alabama and Missouri 406
Imperfection of this sketch 407
Much information wanted within the limits of the Essay ... ib.
Much more for the region beyond them .... ib.
Encouragement to Geologists to collect facts and complete the inquiry .... ib.
Concluding Remarks, on the difficulty of referring the events stated, to epochs in chronology .... ib.

PAGE

INVERSE ORDER OF GEOLOGICAL FORMATIONS.

1. By modern deposites of the great ocean.................. 408
2. Deposites by fresh water.................................. ib.
3. Deposites from saline lakes.................................. ib.
4. The primitive foundation of the globe..................... ib.
My own opinion on the subsidence of the ancient and original ocean; as water was (a) turned to gas to form the atmosphere; (b) converted to solids, by crystallization, to form minerals; and (c) by nutrition to constitute plants and animals 409

OTHER AGENTS.

The hypothesis of a stroke from a Comet.................... 410
Of a vast Inundation from the southeast.... ib.
Of a change in the Axis and Equator of the earth forty-five degrees 411

APPENDIX.

Abstract of the Protogæa of Leibnitz 413
Description of the country south of Lake Erie 417
Classification of American Fossil Shells, &c. 419

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Bird's eye view of the front, or small upper grinder of the right side of an American Mastodon, dug up in the town of Hempstead, Rockland county, state of New-York,—about 34 miles from the city of New-York.—Length, 4 5-8 inches, breadth, 3 1-8 inches.

Fig. 2. Bird's eye view of a tooth dug up in Middletown, Monmouth county, state of New-Jersey, about 26 miles from the city of New-York.—Length, 9 6-8 inches—breadth, 3 1-8 inches. It is supposed to be allied to the Asiatic Elephant.

Fig. 3. Bird's eye view of a tooth found on the Eastern shore of Maryland. (From Dr. Hayden.) Length, 8 1-2 inches—greatest breadth, 4 inches. It is supposed to be allied to the African Elephant.

Fig. 4. Side view of Figure 1, with the roots broken.

Fig. 5. Side view of Figure 2.—Showing the internal part of the tooth, the external lamina of bone having cracked off. The white substance exposed in this view, was of the same friable nature as that in the roots of Figure 1, and 4.—Greatest depth, 8 1-2 inches.

Fig. 6. Side view of Figure 3.—Greatest depth, 9 2-8 inches.

PLATE II.

Fig. 1. Exact view of the tusks of a large animal discovered by Drs. Mitchill and Townsend, at Chester, Orange county, state of New-York, in May, 1817.—They were denuded lying in this horizontal position. The tusks were smooth, and of a yellowish brown and mottled appearance. This elegant surface was traceable all around and above the upper grinders, which were seated, as here represented, in the tusks themselves. The sharp edge of bone which seems to have surrounded the roof of the mouth, and which is seen to terminate behind, in condyloid surfaces, for the reception of the cervical vertebræ, was afterwards exposed. The space within this circle of bone was so mutilated and crumbled, that an exact delineation could not be taken. The two triangular flat plates of bone, observed at the divergence of the tusks, were continuous into them, and not divided by sutures. It will be seen, however, that they are separated from each other their whole length, by a longitudinal fissure, until they are lost in the convergence of the tusks. The posture of the animal was supine, or on his back, and he had lain in this manner, probably undisturbed, since his death. The length of the left tusk, which was wholly exposed, is 9 feet along the curve. It made a bold curvature outward and a little upward. The right tusk was 7 feet along the curve, and had a direction in a plane, diverging very little from a perpendicular. These bones lay about 6 feet below the surface. Diameter of each tusk at the divergence, 8 2-3 inches. Greatest breadth of the circular edge of bone, 25 inches. Distance from the condyloid surfaces to the upper grinders, 18 inches.

Fig. 2. Side view of the lower jaw with the two grinders in siture.—Length, from the condyle to the extreme point of the chin, 36 inches. Length along the base, 30 inches. Length of the front, or smaller grinder, 3 5-8 inches. Breadth, 2 7-8 inches. Length of the larger, 6 1-2 inches. Greatest breadth, 3 1-2 inches.

Fig. 3. This thin flat plate of bone lay about ten feet deeper, and immediately under, and parallel to the circular edge of bone already described. It is separated by a longitudinal suture, and before its bifurcation is contracted in its breadth, and bent down to form a sinus on each side, apparently for the reception of temporal muscles.

Fig. 4. Relative direction and position of the tusks, with a conjectural view of the shape of the cranium, and the manner in which it was probably associated to the lower jaw. The dexter tusk was shorter, stouter, and more crooked than its fellow : The point had the appearance of having been worn and blunted by use. Its form afforded abundant evidence of the preference the living animal had given to the right side.

PLATE III.

Fig. 1. Back or large upper grinder of the right side. Length 6 inches. Mean breadth, 3 inches.

Fig. 2. Bird's eye view of half the lower jaw, displaying the angle of divergence. There was enough of the right side left to show its direction.

Fig. 3. Perpendicular section of the aveolar progress of the right branch of the lower jaw, giving a view of the large or back grinder, and direction and figure of the roots. They are hollow, and the external lamina of bone is seen peeling off.

Fig. 4. Tooth and part of the jaw of a creature resembling the fossil animal of Maestricht. It was found at the base of the Neversinck hills, in New-Jersey, among belemnites and oyster-shells.

Fig. 5. A belemnite, from the same stratum.

Fig. 6. Petrified echinus from Kentucky. They are said to be frequent in the Great Cavern, near the Green river.

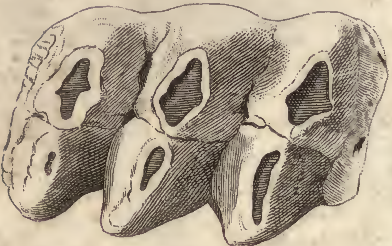
Fig. 7. Petrified echinus, from the upper country of Georgia. There were many more at the place whence these were taken.

Fig. 8. Red oxyd of iron, containing encrinites and shells, from Oneida county, New-York.

FINIS.

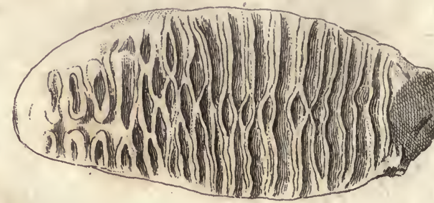
FOSSIL TEETH of the NEW-YORK MASTODON and of NORTH AMERICAN ELEPHANTS.

1



2

3



Top & Side of a Tooth from New Antrim, Rockland County, N.Y.

4

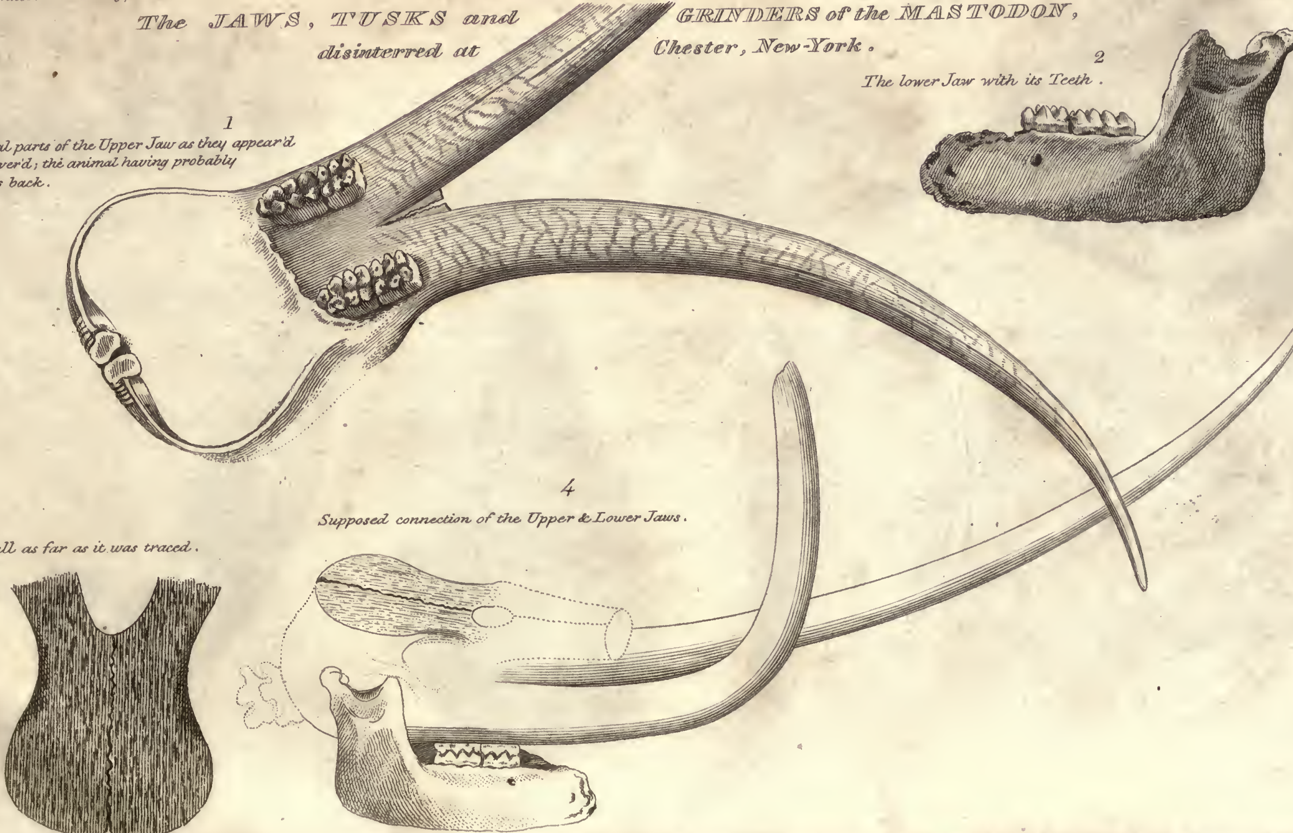
Top & Side of a Tooth from Middletown, Monmouth County, N.J.

5

Top & Side of a Tooth from the Eastern shore of Chesapeak bay, Maryland.

6

The JAWS, TUSKS and GRINDERS of the MASTODON, disinterred at Chester, New-York.



1

The several parts of the Upper Jaw as they appear'd when uncover'd; the animal having probably died on his back.

2

The lower Jaw with its Teeth.

4

Supposed connection of the Upper & Lower Jaws.

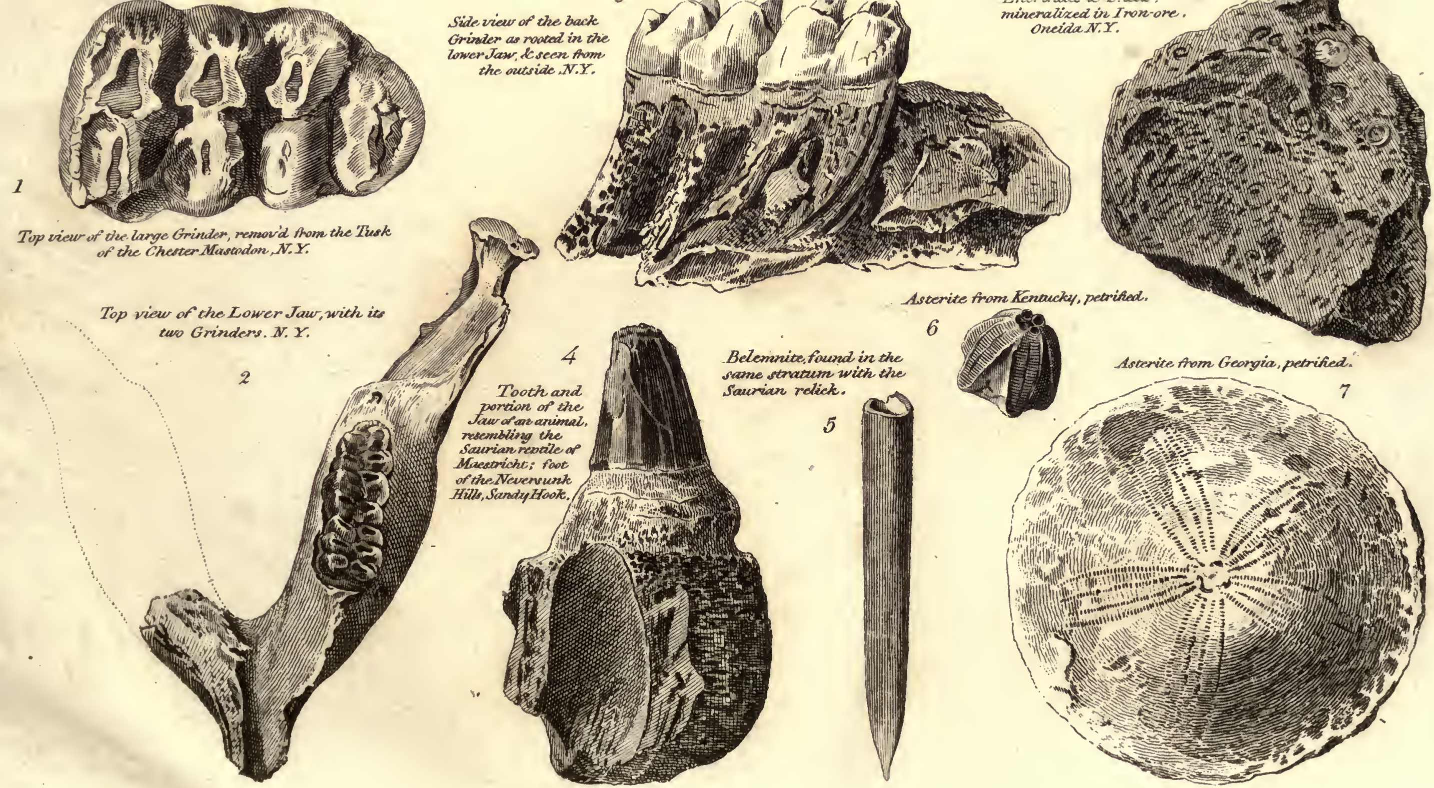
3

The Skull as far as it was traced.

P. S. Townsend M.D. del.

New-York, Publish'd by Kirk & Mercein, 1818.

A. Anderson sc.



1 Top view of the large Grinder, remov'd from the Tusk of the Chester Mastodon, N.Y.

Side view of the back Grinder as rooted in the lower Jaw, & seen from the outside, N.Y.

mineralized in Iron-ore, Oneida N.Y.

2 Top view of the Lower Jaw, with its two Grinders. N. Y.

4 Tooth and portion of the Jaw of an animal, resembling the Saurian reptile of Maestricht; foot of the Neversunk Hills, Sandy Hook.

5 Belemnite, found in the same stratum with the Saurian relick.

6 Asterite from Kentucky, petrified.

7 Asterite from Georgia, petrified.

A. Anderson del. & sc.

New-York, Publish'd by Kirk & Mercein — 1818.